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ARMY ORDNANCE

VOL. IV WASHINGTON, D. C., MAY-JUNE, 1924 No. 24

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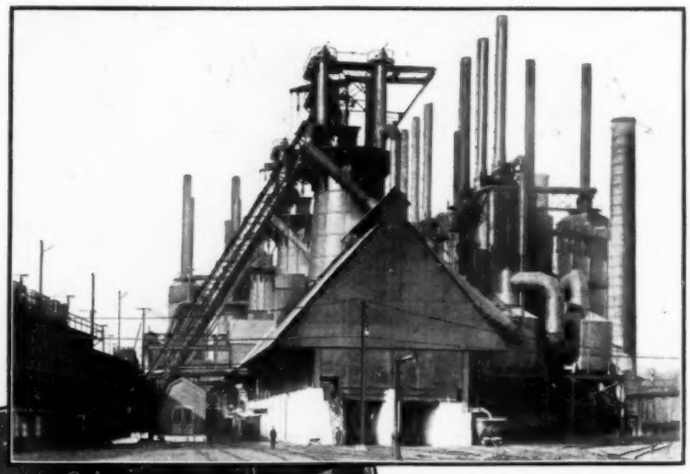
At right: Blast furnaces, converting ore into iron. Below: Open hearths, where the iron is converted into steel.



Below: 14,000-ton hydraulic forging press in operation.

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ARMY ORDNANCE

THE JOURNAL OF THE ARMY ORDNANCE ASSOCIATION

Pledged to Public Service in Effecting Industrial Preparedness for War as Our Strongest Guarantee of Peace

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WILLIAM W. COLEMAN, *Vice-President*

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The National Screw Thread Commission

Created by Act of Congress, the National Screw Thread Commission has accomplished excellent results in standardization of screw threads—a work of great importance in industry and in the quantity production of Ordnance materiel. The members of the Commission, from left to right, are: Front row, F. O. Wells, representing The American Society of Mechanical Engineers; Dr. W. S. Stratton, former Director, Bureau of Standards; Colonel John Q. Tilson, member of Congress from Connecticut, representing the Congress of the United States; Major J. O. Johnson, representing the Ordnance Department of the Army, and Commander J. N. Ferguson, representing the Navy Department. Back row, Commander M. A. Libby, representing the Navy Department; Ralph E. Flanders, representing the American Society of Mechanical Engineers; Major Earle Buckingham, representing the Society of Automotive Engineers; George S. Case, representing the Society of Automotive Engineers, and H. W. Bearce, of the Bureau of Standards, Secretary to the Commission. Dr. Stratton, now President of Massachusetts Institute of Technology, has been succeeded on the Commission by Dr. George K. Burgess, Director of the Bureau of Standards. Col. E. C. Peck, who is not shown in the picture, is a member of the Commission, representing the Ordnance Department of the Army.

Editorials

The Importance of Gages in Munitions Manufacture

THE greater part of this issue of ARMY ORDNANCE is given over to discussions on gages—what they are, and why they are, and their extremely important relation to Ordnance. We believe this to be a subject that is generally under-valued even by those who concede the importance of Ordnance in general. We therefore feel that all readers can find something of profit and broader understanding in the articles which follow.

In an address at the first annual meeting of the Army Ordnance Association at Aberdeen, October 24, 1919, General John H. Rice, Chief Ordnance Officer, A. E. F., said: "The neck of the bottle so far as concerns preparedness for war is the ability of a nation to produce munitions." The inherent truth of this theorem is becoming more and more apparent and more generally accepted as time goes on. Even the most obdurate among the "die-hards" are beginning to see the light.

But devotees of Ordnance are generally afflicted with a malady that bothers all specialists: their own specialty is the one most important feature of the entire subject. Thus, for the ammunition specialist ammunition is the neck of the bottle, to the gun specialist guns are the neck of the bottle, and so on.

When all is said and done every essential component of a complete mechanism is as important as every other component. Witness the trouble and delay caused by the lowly booster during the World War. But gages apply to all matériel, and, in so far as they are the key-stone of quantity manufacture, it is no exaggeration to say that they are a very important neck of a many necked bottle, and that they deserve and require the attention of all who are interested in Ordnance development. It is hoped that the gage articles of this issue will more firmly convince those who already understand—and will convert those who do not—to the vital importance of gages in the design and manufacture of ordnance.

WAR DEPARTMENT
OFFICE OF THE ASSISTANT SECRETARY
WASHINGTON, D. C.

April 21, 1924.

Benedict Crowell, President,
The Army Ordnance Association,
Washington, D. C.

My dear Mr. Crowell:

I want to acknowledge the help which the Army Ordnance Association has given and is giving my office in its work of organizing the industries of the country for national defense.

As Assistant Secretary of War during the World War, you know as no one else in the country the need for this work and its great importance. The work of the parent body of the Army Ordnance Association for the past four years and the work of recently established local posts have been of great value in educating the general public to our needs and in securing its assistance in the work. The assistance of the Association has been particularly effective because it has been organized and has been able therefore to direct the efforts of its members to the performance of a patriotic service of incalculable benefit to our country.

I trust that my office during the remainder of my tenure and during the tenure of my successors in the years to come may continue to have the support and assistance of your organization.

Very sincerely yours,

DWIGHT F. DAVIS,
The Assistant Secretary of War.

The New York Industrial Mobilization Drill

ELSEWHERE in this issue is a detailed account of the Industrial Mobilization Test held in the New York Ordnance District April 6, 1924. The war game is no longer the monopoly of fleets and regiments. It is now common to industry as well, and the New York District test has demonstrated the practicability of our war plans, and, in some respects the need for further detailed study. Those who participated in the test mobilization and those who arranged and directed it deserve the congratulations and thanks of every one interested in adequate industrial preparedness.

It was auspicious to hold the test on April 6th—the seventh anniversary of our entrance into the World War. It takes no strain of the imagination to picture the impossibility of such an occurrence on April 6, 1914. Then industrial preparedness had not been raised to the dignity of serious thought. As a matter of fact, in those days industry was generally conceded to have no connection with such a far-fetched topic. National defense had been discussed by the Constitutional Fathers, and they had determined its status once and for all. It needed no revision, it required no change! We had our Regular Army, our Navy, our National Guard, we had a friendly neighbor to the north, a spasmodic but harmless friend to the south, and stretches of beneficent sea to the east and west. We were the self sufficient walled city of the past and no strategist could weaken the natural God-given barriers that protected us. But we lived to rue the day! Among the thousand and one lessons taught by the World War not the least was this: that great battles are determined as much by the draftsman at his board, the scientist in his laboratory and the engineer in his plant as by general and doughboy in the din and horror of conflict. Preparedness is a matter of study and planning, of alertness and circumspection, of energy and perseverance!

What the New York Ordnance District tested other Ordnance Districts throughout the country are preparing to test. Then the entire nation will hold a munitions preparedness drill so that the industrial war game may soon eclipse in magnitude—as it already equals in importance—the military and naval war games of ships and men.

The Army Industrial College

ON February 1, 1924, the Secretary of War established in the War Department The Army Industrial College under the direct supervision of the Assistant Secretary of War "for the purpose of training Army officers in the useful knowledge pertaining to the supervision of procurement of all military supplies in time of war and to the assurance of adequate provision for the mobilization of matériel and industrial organization essential to war-time needs."

The new college is another step toward the complete fulfillment of the National Defense Act and the assurance of adequate industrial preparedness. The school will be directed by a nucleus of trained men qualified by study, research, and experience for the momentous task of procurement of munitions and supplies for the military establishment in war.

This latest addition to industrial preparedness is a means of taking time by the forelock and aims to place the mobilization of industry on as scientific a basis as are the other functions of the military organization. It will once and for all explode the old canard that the soldier is primarily a man of arms and knows little of the industrial life of the nation he commands. In a word, this new school will devote itself to industry in war and will teach those who must carry on in the future the lessons learned at great expense of time, effort and life in the World War.

The Assistant Secretary of War and the War Department are to be congratulated. The mobilization of industry for war is now on a thoroughly practical basis. The Army Industrial College will be productive of far-reaching results.

Who's Who in This Issue

COLONEL John Q. Tilson, author of the article on "Gages and National Defense," is now serving his fifth term in Congress from the Third District of Connecticut. He is one of the few men in public life who understand the importance of gages in their relation to quantity production of Ordnance. Col. Tilson was instrumental in the establishment of the National Screw Thread Commission by Congress, and he is an enthusiastic proponent of the Government plans for national defense.

Major General William Crozier, retired, served as Chief of Ordnance from 1901 to 1918. His article on "The Engineering Expense of War Preparation" was given as an address before the Engineers Club of Philadelphia. General Crozier with his wealth of experience and his long service as Chief of Ordnance is well qualified to discuss this topic.

Colonel Frederick H. Payne has written an interesting article on "The Place of the Gage Maker in Modern Industry." Colonel Payne is President of the Greenfield Tap and Die Company, one of the foremost manufacturers of gages in this country. The Company is one of the oldest producers of screw cutting tools and machine tools and has a long and honorable record in this field.

"Interchangeable Manufacture and Munitions" is by Major Earle Buckingham, Engineer of Standards of the Pratt and Whitney Company. Major Buckingham is a member of the sectional committee which formulated the Standards for Tolerances and Allowances for Machined Fits, a portion of which appears in the Professional Notes Department of this issue.

Major Earl McFarland, author of "Gaging the Springfield Rifle" is Commanding Officer at Springfield Armory, Springfield, Massachusetts, the home of the Springfield Rifle. His discussion of the various gaging operations of the barrel and receiver of the rifle are the result of a first hand understanding of the situation. Several portions of his article are taken from a thesis submitted to the Worcester Polytechnic Institute from which he has recently received the degree of Mechanical Engineer.

Fred Olsen, author of the paper on "Under Water Storage of Smokeless Powder" is a research chemist at Picatinny Arsenal and is one of the foremost explosives experts in the Ordnance Department.

Col. E. C. Peck needs no introduction to our readers: articles from his pen have appeared in recent numbers of this magazine. In addition to being one of the national authorities on gages, he is chairman of the Sectional Committee on Tolerances and Allowances for Machined Fits and a member of the National Screw Thread Commission. He served with distinction in the Gage Section of the Ordnance Department during the war.

Dr. George K. Burgess, a scientist of international fame, is Director of the United States Bureau of Standards. His article "Precision Measuring Instruments in Gage Inspection" is a detailed description of the various kinds of instruments used in gage inspection work, and should prove a valuable contribution to the scanty American literature on this subject. Dr. Burgess is doing excellent work at the Bureau and his cooperation with the work under way on ordnance investigations has been productive of excellent results.

Mr. W. L. Whitmarsh presents a thorough discussion of measuring instruments in his article "Modern Precision Measuring Instruments." He is an engineer on the staff of the Brown and Sharpe Manufacturing Company. Mr. Whitmarsh discusses many of the better known precision measuring instruments as well as some of those of less common use.

Major J. O. Johnson, Chief of the Gage Section, Office of the Chief of Ordnance, contributes an interesting story on "How the Ordnance Department Has Solved Its Gage Problem." Major Johnson has been in charge of gage work in the Department since shortly after the World War and upon him fell the tremendous task of assembling, classifying and storing the gages used during the war.

Major William A. Borden, former Chief of the Aircraft Armament Division, Office of the Chief of Ordnance, and now stationed at Aberdeen Proving Ground, completes in this issue his excellent treatise on "Bombs." He has covered the entire subject including also the construction and use of bomb sights. In this issue he explains bomb fuzes in a very thorough manner.

Dr. W. L. Sherrick completes the results of his research work on the explosibility of ammonium nitrate in his article "The Influence of Density of Packing Upon the Explosibility of Ammonium Nitrate." Dr. Sherrick was formerly a research engineer with the Bureau of Mines. His investigations were carried on in conjunction with the National Research Council and represent the findings of the Committee appointed to investigate the explosibility of this substance.

Gages and National Defense

By

COL. JOHN Q. TILSON

IT is appropriate that the Representative in Congress from the New Haven, Connecticut, district should contribute an article for the Gage Number of ARMY ORDNANCE, for it was just outside the city limits of New Haven, and within a half mile of the place where the present Representative of that district now lives, that the principle of interchangeability of parts in manufacture was first practically worked out and applied in this country, and probably in the world. A letter written by Thomas Jefferson when he was Minister to France, addressed to John Jay, states that a Frenchman named Le Blanc had invented an improvement in the manufacture of muskets which "consists in making every part of them so exactly alike that what belongs to any one may be used for every other musket in the magazine." That the idea was not worked out and utilized, however, is shown in a later letter from Jefferson in which he states that he tried to get the United States to bring this Frenchman over but failed and afterwards he lost track of him. I refer to this in order to give credit where credit is due, although the idea, along with its originator, seems to have been lost. At any rate, the principle of interchangeability of parts in manufacture was not used in France or any other country outside the United States until many years after it was in use here. Eli Whitney, the inventor of the cotton gin, was probably the originator, and, it is claimed quited confidently, was the first to work out and practically apply the principle of interchangeability of parts in the manufacture of fire arms. Although the cotton gin was one of the most important and far-reaching inventions of any age, the difficulties encountered in protecting his patent were so great that Whitney received almost no financial reward from it. We, therefore, find him turning to the manufacture of fire arms, in which he was eminently successful. The great Winchester Repeating Arms Company of today is the direct descendant of the small enterprise in which he embarked.

Col. John Q. Tilson
Member of Congress from Connecticut

In 1798, an order for muskets was given by the War Department to the famous cotton gin inventor, which were to be manufactured "on a new principle." Jefferson, in a letter to Monroe, written in 1801, in speaking of Whitney and his "new principle," says: "He has invented molds and machines for making the pieces of his locks so exactly equal, that take 100 locks to pieces and mingle their parts and the 100 locks may be put together by taking the pieces which come to hand."

About ten years elapsed before the order was fully completed and the Government had to make a number of extensions of time for the completion of the order. Recalling the obstacles to be overcome one hundred and twenty years later during the World War, it is not to be wondered at that some delays were encountered in this pioneer undertaking. In connection with one of these extensions, Whitney brought to Washington all the parts for the assembling of ten complete muskets. The different parts of the musket were segregated into as many groups as there were parts in the musket. In the presence of the Secretary of War and other officials, Whitney performed what then appeared to be the most amazing feat of taking at random a part from each of the groups and assembling the parts into a complete musket. The exhibition seems to have been convincing. At any rate, the time was extended and he was allowed to finish the order.

That the Whitney muskets were more than satisfactory is well attested. In 1847, Jefferson Davis, then commanding a Mississippi regiment in the War with Mexico, wrote to the Ordnance Department that the steel-barreled muskets from the Whitney armory were "the best rifles ever issued to any regiment in the world."

In 1799, an order for pistols was given to Simeon North, of Middletown, Connecticut, and it is apparent from the result that before the completion of this order he used the same principle. It has been contended that North and not Whitney is entitled to first credit for this new

principle. Unfortunately, the papers, drawings, designs and much other data which might give valuable information concerning the work of both Whitney and North along this line were destroyed by fire in their respective shops. It is quite probable, in view of the fact that the two pioneers along this line lived within twenty miles of each other, that ideas were exchanged between them, but, from the records still extant, it appears that Whitney used the "new principle" from the beginning, whereas, in the case of North, it does not affirmatively appear that he used it prior to 1808. In 1813, North contracted to furnish 20,000 pistols, and in the agreement appears this significant clause: "The component parts of the pistols are to correspond so exactly that any limb or part of one pistol may be fitted to any other pistol of the 20,000."

North's first contract with the Government was made in 1799, his last was finished in 1853, a year after his death, aggregating 50,000 pistols and more than 30,000 rifles. It has been said of him that he worked under sixteen administrations, representing all parties, and that in all the fifty-three years he never received a reproof or a criticism of his work. He was a country-bred man, strong, quiet and almost painfully modest. He lacked Whitney's education and influence, but, like him, he represented the best which American mechanical and business life has produced.

Whitney and North: Originators of Interchangeability

Without attempting to positively decide which of these two worthy sons of the same commonwealth is entitled to the credit for originating, or for the earliest development of, the principle of interchangeability, it is sufficient to say that this principle, which has become of such tremendous importance in manufacturing, was, during the first decade of the nineteenth century, developed through the experimental stages by these two notable Connecticut men.

Whatever may have been the form or designation of the tools and other devices used in these early ventures, they were doubtless of a somewhat crude and primitive character. Their use, however, was the beginning of a chapter in American history far more important than the threatened wars for which the muskets were to be made, which have been almost forgotten.

Interchangeability of parts and the devices necessary to insure interchangeability are pre-eminently American in their use and development. When the principle spread to Europe, as it did before the middle of the nineteenth century, it was universally characterized as the American system. The scarcity and high cost of labor in this country exerted a great influence in the development and use of such a principle. The increased use of labor saving machinery accentuated development in this direction. In fact, it can be said that jigs and gages, in connection with machinery, more than anything else, are responsible for the marvelous development of American manufacturing and for the ability of our manufacturers to successfully cope with foreign competition while paying much higher wages.

The primary credit for the development of the principle of interchangeability is due, as has been shown, to the fire arms industry, although its greatest application has been in the production of such articles as sewing machines, bicycles, typewriters, clocks, watches and tools. The Ford automobile should also be mentioned as a conspicuous example. On account of the comparatively small quantities of military fire arms required in this country, development of the use of gages in the manufacture of military fire arms and other matériel did not keep pace with the development in the industries of peace. From the time that Whitney first used such devices as he did in making interchangeable parts for muskets until shortly before the World War began there had been a very great improvement in the character and quality of gages, and also an increase in their number and use, but not comparable with the development in lines of peaceful industry, so that when we entered the World War the supply of gages and other precision and inspection devices, even for the most used of weapons such as the Springfield rifle, was quite limited. For other important articles there were few or none.

Gage Provisions of National Defense Act of 1916

It may not be generally known that up to 1916 no authority of law existed even for making appropriations for gages, so that an item in an appropriation bill before Congress authorizing money to be spent for such a purpose would have had to go out of the bill on a point of order made against it. Early in 1916, I introduced a bill to authorize the War Department to manufacture and otherwise procure gages, dies, jigs, tools, fixtures and other special devices and appliances for the manufacture of arms, ammunition and other matériel. When the National Defense Act of 1916 was under consideration in the House of Representatives, I offered my bill as an amendment and the amendment was carried as Section 123 of the National Defense Act. In considering the development and present status of the gage problem this section should have a place, so it is inserted here in full:

> Section 123. Procurement of gages, dies, jigs and so forth necessary for the manufacture of arms and so forth,—The Secretary of War, be and he is hereby authorized to prepare or cause to be prepared, to purchase or authorize procurement of such gages, dies, jigs, tools, fixtures and other special aids and appliances, including specifications and detailed drawings, as may be necessary for the immediate manufacture of arms, ammunition, and special equipment necessary to arm and equip the land forces likely to be required by the United States in time of war: Provided, That in the expenditure of any sums appropriated to carry out the purposes of this section the existing laws prescribing competition shall not govern, whenever in the opinion of the Secretary of War such action will be for the best interest of the public service.

The story of what happened as a result of the new provision of law during the few months intervening between its enactment and our entrance into the war is short. The Army appropriation bill for 1917, and the Fortifications bill as well, carried appropriations under authority of the new provision. Very little was or could have been done, owing to the lack of time before war was declared on April 6, 1917. The war found us with little except the law itself upon which to lay the foundation upon which was later constructed a great munitions program.

At the outset of the war it became apparent that the gage problem was a determining factor as to the types and kinds of arms to be used in the struggle. I can best illustrate by taking one element of ordnance equipment as typical and going into it somewhat in detail. I therefore choose the shoulder rifle. For a few weeks after we entered the war there was some more or less pertinent discussion as to the kind of rifle with which the infantry should be armed. A careful observation had been made of all the rifles in use by the allied forces, which only served to reinforce the general belief in this country that the United States Springfield, Model 1903, was superior to any other rifle in the war. It was the arm to which our small Regular Army and our National

Guard had become accustomed and it was quite naturally desired that the emergency army to be raised should be armed with the same weapon. Lack of gages caused the decision to use another rifle.

Soon after the United States had entered the war, a conference of gage manufacturers and rifle manufacturers was called to meet with the responsible officers of the Ordnance Department to discuss the subject of gages as related to the production of rifles. Being greatly interested in the subject matter of the conference, I secured the conference room in the House Office Building as the place of meeting and had the privilege of attending. Representatives of all the larger gage manufacturers in this country were present and stated quite fully and clearly what could be counted upon in this direction. As a result of the conference, it became apparent that for the bulk of our troops some other than the Springfield rifle must be adopted.

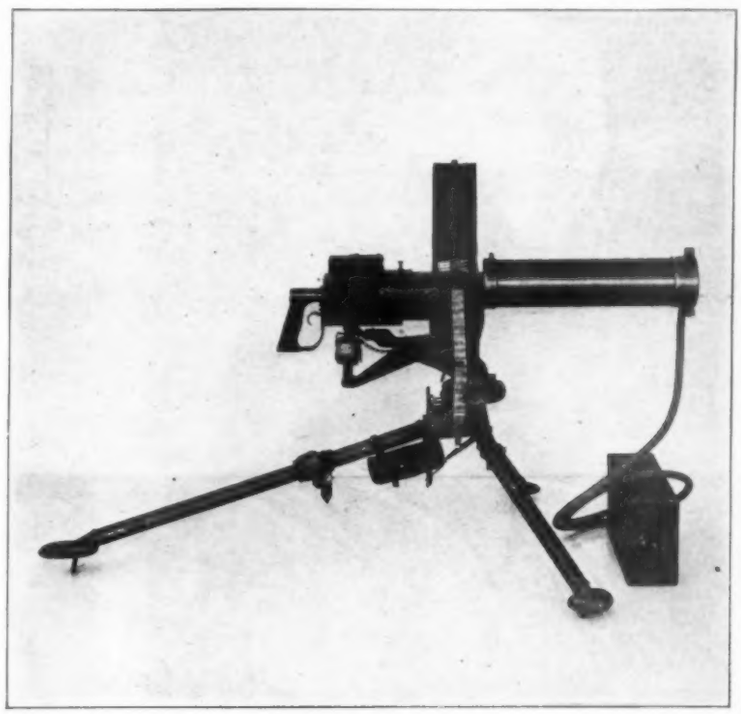
Gage Situation During World War

The situation as to rifles was that when we entered the war in 1917 we had on hand less than 700,000 Springfield rifles. As is well known, this arm is made only in Government arsenals. We had accumulated in the arsenals gages of one type or another to such an extent that our capacity in rifle production was about 200,000 annually, although, of course, nothing like maximum production had ever been attempted. This capacity was quite sufficient in peace time, when all that was required was to replace wastage and very gradually increase the stock on hand. In war, however, such a capacity was not sufficient to even replace wastage, so that relying upon this source alone we must limit the infantry forces to less than 700,000 rifles. Such increase in gage capacity as was found to be practicable without seriously interfering with other features of the munitions program would have supplied little more than the inevitable wastage of war time service. In this situation, it was necessary to turn to sources outside of our Government arsenals and here also the element of gages was the decisive factor.

It was fortunate for the United States that necessity in a great emergency had compelled Great Britain to place very large orders for rifles with American manufacturers and that these manufacturers had equipped themselves with the gages and other necessary tools for quantity production of an improved type of the British Enfield rifle. The practicability of using this equipment with slight modifications saved us from serious embarrassment in our rifle program.

The adoption of the improved British Enfield rifle—designated by us as the United States Model 1917—as our principal reliance for the war is such an interesting illustration of the vital importance of gages in any program of National Defense that a brief reference to it is entitled to a place here. Prior to 1914, the British Ordnance Bureau had been engaged in designing a new rifle, which was to take the place of the old Enfield. The new design was a decided improvement in many ways over the old one. It was to be .285 calibre instead of .303, as was and is now the calibre of the British rifle.

The new rifle, however, had not progressed beyond the blue print stage when the war broke out. Any kind of rifle made of metal is superior to one on paper. Such rifles as were in existence were of the old type. Such facilities as existed for making rifles were of the old type. Such ammunition as was on hand fitted the old rifle and such gages, dies and other necessary tools and equipment as existed for the production of rifles and ammunition were of the old type. Therefore, only one course was open to Great Britain, and that was to continue making what could be made with existing facilities.



Browning Machine Gun
Designing and producing the gages for a machine gun is a tremendous task and requires much time and study

British agents brought drawings for their new rifle—modified so as to use .303 instead of .285 caliber ammunition—to this country and entered into contracts with such as could be induced to undertake its manufacture. The demand for rifles was pressing. At this stage of the British mobilization, rifles were not available for more than one recruit in ten enlisted. American manufacturers were urged to produce rifles with all possible speed. Time rather than money was the most essential element of the contracts. The cry was rifles at the earliest possible moment and then more rifles. Some of the strongest and best concerns in America took these contracts, companies with abundant capital and practically unlimited credit. Peace prevailed here; labor, both skilled and unskilled, was plentiful and yet no rifles were produced for a whole year, the reason being the difficulty of the solution of the gage problem.

The wrestling of American manufacturers with the gage problem during the years 1915 and 1916 was a most instructive lesson in industrial preparedness for war. I watched and studied it with great interest and intensity, believing it to be a most useful lesson for this country to learn. After a year's struggle with the problem, only a few rifles were being produced. Meanwhile, much of the best blood of Great Britain was being shed that might have been saved, because of the lack of rifles. Eighteen months saw the number of rifles on the way to-

wards France rapidly increasing, but more than two years of most precious time had passed before the 1915 orders for rifles had been filled. The rifles were hurried away to France, but the gages and other necessary equipment which had been created for their production and which had been paid for in British gold remained, and saved us from an embarrassing and dangerous situation.

We had entered the war and were now able to use the gages and other equipment created for the purpose of meeting the dire need of Great Britian to likewise meet our own necessity. Comparatively slight modifications were necessary in order to produce a rifle that could use the United States service cartridge, but even this slight change, requiring only a few new gages, held up the rifle program for months.

In the light of our war experience, it is now possible to estimate about what time it would have required to create the necessary gage capacity to have supplied rifles to our armies as they were mobilized and to make good the wastage. One thing is quite certain, and that is, that, if it had not been for the fortunate circumstances referred to, more than two-thirds of the two million men sent to France would have had to use the rifle of either France or Great Britain during their entire service.

Quite as good an illustration of the importance of gages and the time required to procure them is furnished by the machine gun problem. The Browning gun had been designed, made and tested. It was a success. We were practically without machine guns of any kind, while the rapidly increasing importance of this arm was being daily demonstrated on the battlefields of France. The need for machine guns was most urgent. The Lewis gun, chambered for British ammunition, had been put into quantity production. The Marlin Company had equipped itself for making a machine gun for Russia. These two might have been modified, as they were a little later, to use United States ammunition and propably in the light of subsequent events should have been modified at once and manufactured in much greater numbers than they were, while the gage problem for the Browning was being worked out. At any rate, with all possible effort concentrated on the Browning, it was a full year before these guns were being turned out in adequate quantities. Meanwhile our troops in France were inadequately supplied with such French and British machine guns as were available and with all the inconvenience and confusion attendant upon the use of two kinds of infantry ammunition in the same army.

The pistol problem furnished another forceful illustration of the same character, if one were needed. Our officers literally used such pistols as they could get or went without, while the frantic, unceasing efforts of the Ordnance Department to procure the Colt Automatic were rendered practically fruitless until almost the end of the war, by reason of the difficulties necessary to be overcome in working out the gage problem.

Certain components of the artillery program would furnish almost as good illustrations as those already given of the difficulties encountered in trying to work out, in the midst of war, a problem which is peculiarly one of peace. Enough instances have been cited, however, to emphasize the vital importance of this problem in any rational or adequate program of national defense.

The Solution

It is a work that can best be done in time of peace, in fact can be done satisfactorily only in time of peace. A thorough study should be made of every essential component of matériel. Those necessitating the use of considerable gage, jig, and fixture equipment, involving long time and special mechanical skill in manufacture, should be given priority of consideration. The goal should be an adequate reserve of such equipment, kept well up-to-date. Nothing short of this will satisfy the proper demands of a great country which is entitled at all times to a reasonable degree of preparedness for its own defense.

It is a source of very great satisfaction that the Ordnance Department has tackled the problem in a determined manner, indicating that it is not to be allowed to be lost sight of or side-tracked, but is to be worked out with vigor and persistence. The on-coming generations will soon forget the lessons of the great war if allowed to do so. I trust that those who are charged with the responsibility of our national defense will see to it that at least the most vital of the lessons learned at such enormous cost are not forgotten.

New York Post A. O. A. Elects Officers

At a dinner at the Army and Navy Club, New York, March 20th, the following officers of the New York Post, Army Ordnance Association, were elected to serve for the ensuing year:

President: Gen. Guy E. Tripp;

Vice Presidents: Col. James L. Walsh, Chief, New York Ordnance District, *ex officio*, Colonel T. L. Ames, Ordnance Officer, Second Corps Area, *ex officio*, Lt. Col. H. B. Machen, and Lt. Col. R. D. Coombs;

Secretary: Capt. H. W. Churchill;

Treasurer: Capt. J. B. Fidlar;

Executive Committee: Gen. Tripp, Chairman, Col. Walsh, vice-chairman, *ex officio*, Col. Ames, *ex officio*, James A. Farrell, E. R. Stettinius, Col. C. E. Warren, Lt. Col. E. L. Sherwood, Maj. Earl McFarland, J. M. Boyle, Capt. C. E. Davies, Lt. Col. Machen, Lt. Col. Coombs, Capt. Churchill and Capt. Fidlar.

General Tripp addressed the meeting and told of his recent travels through China and Japan. Col. Mervyn ApRice spoke of his experiences as an Ordnance officer with the British troops during the early stages of the World War. Lieut. Clarence Wills, who has just returned from a four years' sojourn in China, told of his experiences there.

The meeting was a most enthusiastic one and was well attended. The New York Post has many important projects under way and the newly elected officers promise a year of fruitful activity.

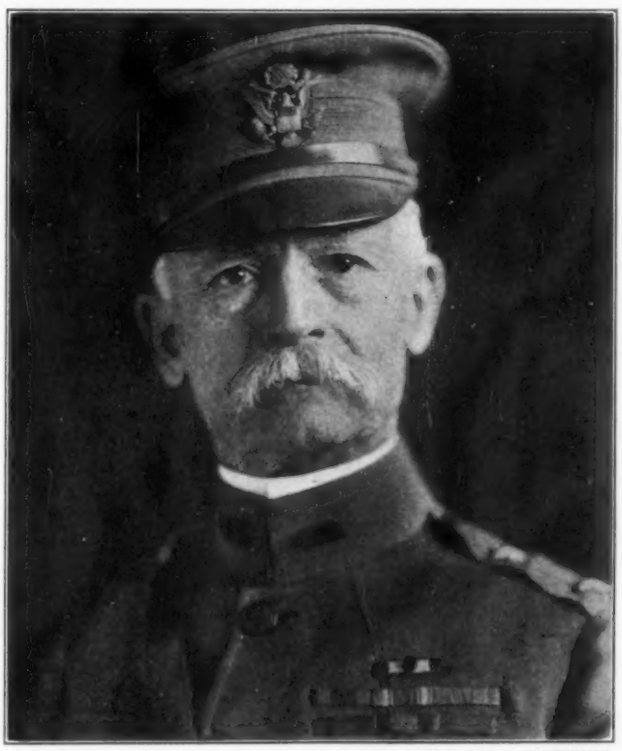
The Engineering Expense of War Preparation

By

MAJ. GEN. WILLIAM CROZIER

IT is characteristic of the engineering profession that when a project is seen to be indispensable the expense attending its execution should be ascertained and faced. Preparation against war forms no exception to this wholesome rule, and I propose to say a word about one phase of it. Both personnel and material are involved, but not with anything like equal expense.

Some twenty years or more ago, after a visit to Germany, President Hadley stated that the service of that country's young men with the colors for military training did not constitute a real expense; for the reason that the economic value of these youths was so much increased by the training that the net result was gain, and not loss. The officers, of course, were a permanent organization, and did not go out after training and render an economic return for temporary support; but they were the school teachers of the soldiery, and if the schooling was worth while the teachers were profitable as a necessary part of it. And the same may be said of the whole permanent nucleus of personnel which was required to keep the instruction going. Our War Department has a program of organization and training for our regular army and civilian reserves which does not call for anything like the time of service with the colors by the reserves that was the practice in Germany, and if our course of military instruction and of physical and mental training is as good as was the Germans' this part of our preparation need not be counted as an expense, according to the high authority of President Hadley, but can be regarded as an investment which will yield an economic return.



UNDERWOOD & UNDERWOOD

Maj. Gen. William Crozier U. S. A. Retired, Chief of Ordnance 1901-1918

Munitions Preparedness

It is different with the material preparation. Material certainly costs money. But here again the kind of material used for the maintenance of the soldier under training, his food, clothing, and other supplies needed to keep him in health and vigor, is no special expense, for he consumes no more of these things than he would if he were following his civil pursuits. Indeed, as he is fed, clothed and sheltered by wholesale while in the government service, it is reasonable to suppose that he is then maintained at less expenditure by the people as a whole than when he is taken care of individually by the same aggregate community. But not so with other kinds of material, with engineering as distinct from what might be called commercial material, the class which has no use except for war purposes. Arms and ammunition are far more expensive, when considered as school properties, than black boards and chalk; and they are still more so when we think of the quantities which should be accumulated and kept in storage for the equipment of the armies which would have to take the field upon the outbreak of war.

Prudence requires that these reserve munitions be kept on hand, notwithstanding that progress in the military art, as in any other, may supersede them, and may require their replacement even before there shall have been occasion for their use. It would be poor policy to refrain from procuring a proper supply of arms on the ground that the progress of invention would subsequently bring along something better. Such progress is always going on, and to give controlling consideration to it would prevent our ever providing for war time armies, which is disquieting in the matter of expense. It need not be anticipated, however, that the whole accumulated supply of a given weapon need be discarded immediately upon the appearance of a better one.

While it is true that war is competition, and that it does not suffice to have good officers, good soldiers and good arms if the enemy has better officers and soldiers and arms, the impossibility of producing quickly the large supply of an important weapon and its ammunition which is required for one of the armies of today usually im-

poses upon belligerents the necessity of fighting the early stages of their wars, and sometimes a whole war, with weapons which, on the proving ground at least, have already been superseded.

World War Examples

The World War afforded several examples of this necessity. At the beginning of the war the French had already produced a better field piece than their famous "75." The new one had a greater range and a greater horizontal field of fire than the old favorite; and an order was in progress for the manufacture of 100 batteries for the Government of Italy. But the expense and the time required for the rearmament of the whole French artillery with the new gun, involving, as it would have, a new set-up of the machine equipment of their manufacturing arsenals, were so great that it was not attempted, and they fought through the war with their gun of the model of 1897.

The British had a similar experience with their infantry rifle. They had for some time been dissatisfied with their Lee gun; had designed a new one, and carried it through the experimental stages, and had tried it out in the hands of troops; but the war caught them before they had gotten the manufacture going, and the time required for changing over the jig, template and fixture equipment of their armories would have been prohibitive; and they too did all their fighting in Europe with their old rifle. It is true that they anticipated a greater need for rifles than their own armories could supply. They placed large orders in this country, which were for the new model, because our factories, not being equipped with fixtures for the manufacture of either, could prepare to make the new one as quickly as the old.

But they issued none of these American made rifles to their troops in Europe. These examples illustrate the value of having a proper supply of munitions on hand, even if they are not of the latest and best model. It would have been fatal to the British and to the French not to have had reserves of these already outclassed weapons.

Our method has always been different. We had on hand a very inadequate supply of machine guns, for example, but we were experimenting with a new model; and so we stopped adding to our supply, to await the outcome of the experiments. And this, notwithstanding the fact that the gun which we already had was a very good one, which was used by some of the principal belligerents all through the war, and is still good enough to be manufactured and sold. This incident occurred in 1915, when the war in Europe had already been going on a year; and the result was that our troops in the field had to fight with French machine guns.

The Cost of Preparedness Insurance

We must face the fact, however, that the expense of preparation of material is not offset, as is the personnel expense, by any items on the other side of the ledger; and we must be content to look at this expense for what it really is, as one incurred for insurance. It is perhaps fortunate that it comes in connection with the output of such a sane body as the engineering profession; for this supports the hope that the members, having an appreciation of the needs and the possibilities, may lend their aid to a better realization of the military program than it has been possible to secure in the past. I am not going to give you sets of figures of appropriations which the War Department would like to have from Congress—that is no longer my business—and I am not going to complain of that body for its failure to meet the figures which have been so often presented to it. In the course of a long experience with it, I have found that the Congress is usually a lap or two ahead of the constituencies of the members in the matter of willingness to incur military expenditures. I have often been told by members of Congress that a vote for a military item, instead of being counted as a merit, had, more likely, to be explained in extenuation when the member was up for reelection by a constituency which knew all about his attitude towards the tariff, the control of the trusts or the regulation of the railroads, but had no interest in his views upon any military question. When, in 1915, our very moderate machine gun production was held up and reduced to zero, I am afraid that the Engineers' Club did not do anything about it; and in so withholding action followed the example of every constituency in the country.

Industrial Preparedness

But things are better organized now. The industrial preparation for war has been segregated, and placed under the charge of an able and energetic Assistant Secretary of War; the country has been divided into manufacturing districts, as you have recently been told at an engineering meeting in New York. It is hoped that the manufacturing establishments in each will fit themselves for the production of special articles of munitions which are designated to them as most appropriate for their particular equipment. The manufacture of small quantities of these articles, under trial orders, will not usually afford any profit, and will undoubtedly require time and care and attention for which a return cannot be promised in the form of orders in quantity in time of peace, and of which the irksomeness may only be endured through a sense of duty.

Here is where members of the engineering profession will come in. Many of them will be in charge of departments where this kind of work will be offered as a task, and where their patience will be tried by the "finicky" requirements of what will seem to be a small matter. Many others will be in positions where the influence of understanding may be brought to bear to encourage Congress to sufficient liberality so that even trial orders in proper number and distribution may be provided for. If a small part of the devotion which impelled the engineers of the country to offer themselves for any and every kind of service in the World War may be counted upon to actuate them in the kind of peace time service which I have described, the plans of the War Department will be usefully forwarded, and the profession will not fail the nation *before* the declaration of war, as it has never failed it afterward.

Editor's Note.—This address was delivered before the Engineers' Club of Philadelphia, March 18, 1924.

The Place of the Gage Maker in Modern Industry

By

F. H. PAYNE

GAGES, by which manufactured material is measured and tested to determine its practical interchangeability, are produced in quantities by a very limited number of manufacturers, who have the necessary equipment and the experienced personnel to undertake this very important work.

Gage making, as an industry, is of recent development. In keeping with the general trend of manufacturers to specialize on a given product, the gage-making industry has been developed by those firms who have specialized in the production of gages and have spent a large amount of money in developing special equipment so that they can produce gages with greater accuracy and with greater speed. Gage manufacturers are constantly improving their methods of production, not only to increase the degree of accuracy of their product, but also to reduce the cost. They are constantly improving the design and application of gages. This work is done much more effectively by them than it could possibly be done by the individual manufacturer because of the variety of problems and requirements that are being constantly put up to them, their cumulative experience, etc.

PIRIE MAC DONALD

Col. Frederick H. Payne
President, Greenfield Tap and Die Corporation

Scarcity of Qualified Personnel

In the past the manufacturer of a product produced his own gages, which were few and simple, and they did not have to be made to any special degree of accuracy. The help and equipment at hand was ample to take care of this kind of gage work because, with the exception of a very few industries, the production was not large and present day interchangeable manufacture had not been perfected. And further, help sufficiently skilled was easy to obtain; but today the situation is entirely different.

Today gages are required by practically all classes of metal manufacturers and there is a very limited number of skilled gage men available, especially compared with the vast quantity of gages produced, and consequently it is necessary for the economical production of gages that they be produced by gage manufacturers who specialize in this class of production. Due to the volume of production these manufacturers have the opportunity of perfecting a trained personnel with a varied experience, and are able to carry on experiments leading to constant improvement in construction and design. Gage makers are scarce because it requires a long period of training to acquire the additional experience to do precision work, and only a few have the ability required to become expert and these men frequently leave gage making to take up other work.

The question of material, the quality of steel used, is of such importance that a special committee, composed of representatives of the Gage Manufacturers, Steel Makers, Gage Users, and Government Departments, including the Ordnance Department of the Army, the Navy, and Bureau of Standards, is studying the wearing qualities and permanency of steels suitable for gages. The committee is cooperating with the Bureau of Standards.

The Chief of the Gage Section of the Ordnance Department was instrumental in starting this committee, as he realized how vitally important it was that the proper steel be used in the production of gages, not only to the industry in general, but to the various departments of the government, and particularly to the Ordnance Department.

The gage manufacturer must be conversant with the materials best suited for the various kinds of gages and the proper heat treatment to give the best results. Naturally enough, firms that specialize in the production of gages are in the best position to keep up-to-date on this information.

The gage manufacturing firms today produce far more than just a piece of steel finished to a required size. Every gage is the result of experience, research and experiment. The production of even the smallest and simplest gage requires an accurate knowledge of materials, heat treatment, workmanship, and precision measurement to give the user satisfactory results, and to duplicate these results requires constant care and inspection.

Service Rendered by Gage Manufacturers

The setting of tolerances and allowances for the product is a service frequently performed by the gage manufacturer, and he can always give valuable advice on problems of this nature, because of familiarity with problems of a similar nature.

Production in all branches of the metal-working trade requires gages of a wide variety of design and of varying quantities. In most cases, production would be entirely tied up if the manufacturer were deprived of gages. Gages are the main guide of modern production. They are the main protection against loss from imperfect work. Many manufacturers have found that the installation of an adequate gaging system paid for itself many times in the savings resulting from the reduction of scrap work.

The use of gages has a decidedly beneficial influence on the method of manufacture of a product. For a new product, the dimensions and functions of the parts to be gaged are given careful attention and the proper working allowances and tolerances are set. The setting of these allowances and tolerances determines the dimensions to which the gages are made and focuses the attention of the engineering and production departments on the necessary accuracy required. The result of this detailed study frequently leads to improvement in the design of the product. This does not mean that the resulting work is more expensive. As a matter of fact, the contrary is true.

Proper gages give the production department the maximum amount of lee-way for the producing of parts and, at the same time, produce parts which function properly. Without the use of gages, the production department would usually have to make work to fit, with the consequent excessive cost.

The use of gages is constantly increasing. Industries which have in the past been using few gages are now using them more extensively. The uses of the "limit gage" are increasing very rapidly, and "special purpose gages" are constantly being developed to meet the demands of production. Advance in gaging has been met by the gage manufacturers, who must always be prepared to reproduce measurements with a much greater degree of accuracy than that required by the user. With the assistance of the Bureau of Standards, the manufacturers have improved their equipment and their methods of production and measurement to meet this demand, and have prepared the way for the establishment of more improved methods and standards that are certain to be required.

The Gage Manufacturer and Industrial Preparedness

It will be seen from the above outline of the production and use of gages that the gage manufacturer is of great importance in the present day commercial production program. But considered in relation to Industrial Preparedness in time of war, the importance of the gage making establishments cannot be over-estimated. From the experience of the last emergency, we know that the whole production program hinges on an adequate supply of gages. Today we would not be in a position to secure emergency help in gage-making as we were 10 years ago, as the present day system does not produce the number of experienced men who could be worked in to relieve the situation. So, at the present time, gage manufacturers are of utmost importance in the consideration of the various factors of industrial preparedness, and it is imperative that plans be so made that they devote their maximum production to this most important product in case of necessity.

As a part of a preparedness program, there should be plans for the perfection of gage designs for all accepted units of equipment; and each new unit, as it is adopted, should have a gaging system carefully worked out and parts, in sufficient quantity, should be produced to test their proper functioning before the necessity arises. This would require a comparatively small outlay of money, but would be of the utmost saving of both time and money, as the men available with the sufficient knowledge of the requirements of interchangeable manufacture and proper gaging methods are strictly limited. When work of this kind is rushed through or put through with inexperienced men, countless cases of expensive delay and loss result.

These delays, to a very large extent, can be avoided if plans are carefully worked out in advance. The expense required to do this would be an exceedingly cheap form of insurance against loss which would otherwise be sure to result in case of an emergency.

Army Ordnance Delegates to A. S. M. E. Spring Meeting at Cleveland

Honorable Benedict Crowell, President of the Army Ordnance Association, and Cols. Eugene C. Peck, James B. Dillard, and James L. Walsh, Chief of the New York Ordnance District, have been chosen as special delegates representing the Army Ordnance Association at the Annual Spring Meeting of the American Society of Mechanical Engineers at Cleveland during the last week in May. One of the outstanding features of the meeting will be an address by the Secretary of War on Wednesday evening, May 28. The Secretary will speak on "Industrial Preparedness as Insurance Against War."

This is expected to be one of the largest meetings ever held by the A. S. M. E. Other organizations which have been invited to participate include: The Cleveland Chamber of Commerce, The Cleveland Engineering Society, American Society of Civil Engineers, American Institute of Mining Engineers, American Institute of Electrical Engineers, the American Legion, and the American Society of Military Engineers.

The American Society of Mechanical Engineers has always cooperated with the A. O. A. in the interests of adequate preparedness. Needless to say, it is hoped that this meeting of the A. S. M. E. will achieve the success which has attended these gatherings in the past.

Interchangeable Manufacture and Munitions

By

EARLE BUCKINGHAM

INTERCHANGEABLE manufacture consists of machining the individual parts of a given mechanism within such limits of size that they may be assembled without additional fitting or further machining. Component parts thus made may also be replaced or transferred from one mechanism to another without detriment to the functioning and without fitting. The advantages of such a method of manufacture are self-evident, and are of the greatest value in the production of war munitions. It is obvious that with proper equipment and control, the component parts of various commodities can thus be manufactured in large quantities at a low direct labor cost in widely separated manufacturing plants. In case of necessity, such as arises when large quantities of war munitions are required, this method of manufacture enables existing plants to be utilized to the greatest advantage.

Major Buckingham

To manufacture any commodity on an interchangeable basis, an almost infinite number of details must be taken care of. For example, when a mechanism is built by one man or a small group of associates, and mating parts are fitted one to the other, the information required in the shop is relatively slight. Any data that may be lacking is supplied from the experience and skill of the mechanic who is shaping the parts. He knows exactly where each part is going and what duty it has to perform.

Interchangeable manufacture in large quantities requires, however, that the manufacturing operations be divided into simple and elementary tasks. These tasks require the minimum of skill and experience from the operators. Under these conditions, the operator seldom has the slightest conception of the use to which his handiwork will be put. The skill and thought, however, when not supplied by the operator, must be provided in some way; it cannot be eliminated. This feature of production in itself creates many perplexing engineering problems, the solution of which requires the best thought and skill that can be brought to bear upon them.

There are certain fundamental principles of interchangeable manufacture which cannot be ignored if the full benefits of the process are to be secured. The following paragraphs trace briefly the progress of a commodity through all stages of its manufacture, from its inception as a mechanical project to the final testing that determines its successful completion. An attempt has been made to single out for special comment those factors which make possible, or promote, the interchangeable manufacture of parts.

The development of any new mechanism starts with a mental conception of some function to be performed. This conception then takes detailed form, first mentally, then on paper, and finally in metal. The experimental model—if such be constructed, is often made by the cut-and-try method. Little attention is paid in the beginning to future manufacturing requirements. The main object is to construct a mechanism that will function properly regardless of the exact design. When this end is reached, what may be called the inventive or functional design, has demonstrated its success.

Before manufacturing in quantity is begun, a manufacturing design must be perfected which will modify the inventive design so as to allow its economical production on a large scale. Many manufacturers recognize this twofold nature of designing, and maintain a separate department for each. Those who do not, are confronted with the necessity of making almost countless changes in design of greater or less extent while in production. Such changes are extremely expensive, and the majority of them are inexcusable. Indispensible as is the original invention, it is the manufacturing design which largely determines the success or failure of a given project. Many of the difficulties in the production of war munitions during the World War were due to the fact that no attempt had been made to develop manufacturing designs of the commodities required, and this principally due to lack of time.

Clearances

Clearances are vital factors in interchangeable manufacture. Fits can be secured without interchangeability, but the latter cannot be maintained without proper clearances. It is self-evident that some space must be left between operating parts. The minimum clearances should be as small as the assembling of the parts and their proper operation under service conditions will allow. The maximum clearance should be as great as the functioning of the mechanism permits. The variation between a maximum and minimum clearance determines the manufacturing tolerances. It is clear, then, that by determining at the outset the permissible clearances establishes also the extent of the tolerances.

Clearances should be one of the principal considerations in developing the manufacturing design. This design should aim to allow the greatest possible amount of clearance between companion parts. The more the design lends itself to this end, the greater the economy of manufacture and the greater the degree of interchangeability obtainable. In determining which parts of a mechanism can be made interchangeable, this matter of permissible clearances plays the largest part. A mechanism which is so designed that it cannot permit fairly liberal clearances is not a suitable one to be manufactured on a strictly interchangeable basis, unless the design provides for suitable adjusting means to maintain the close clearances. Every operating part of a mechanism must be located within reasonably close clearances in each plane. After such requirements of location are met, all other surfaces should have liberal clearances.

Tolerances

The general tendency in the past has been to establish manufacturing tolerances by trying to hold the product as closely as possible to a fixed size. The natural result of this policy is that the tolerances established on paper are often exceeded; yet the actual working variations remain unrecorded, because it is argued that under certain conditions the original requirements might be met, and therefore, the tolerances noted are the proper ones, even though they are not maintained. Every effort to make the recorded tolerances represent the actual working tolerances is opposed on the ground that such a proceeding would lower the shop standards. As a matter of fact, it is hard to understand how anything could lower the standards of the shop more than the absolute disregard of the rules it is supposed to be obeying.

There is a further argument for the acceptance of liberal tolerances. Too often in manufacturing, one finds details being made ends in themselves rather than means to an end. In producing a component part, the main object should not be to demonstrate how closely a fixed size can be approached; the aim should be to construct, as economically as possible, a mechanism that will satisfactorily perform certain functions. The knowledge of how accurately a machining operation can be performed is indeed invaluable in making the manufacturing design; but when that design has once been completed, interest should shift to the proper functioning of the completed mechanism.

The proper minimum clearances can be determined quite readily and definitely for most cases in the early stages of the work, but the maximum clearances become established only after extended experience with the particular mechanism. In many cases the extreme maximum is never found because long before that point is reached, the tolerances have become so liberal that there is no need to increase them further.

Component Drawings

Component drawings have two main functions to perform. The first is to give such information about the design and the tolerances that the manufacture of the product can begin. This does not seem like a very difficult task, but the notation of tolerances on component drawings has created new problems of interpretation that have not, as yet, been fully solved. At the present time the language of drawings is not altogether clear and exact.

The first tendency in introducing tolerances on drawings seems to have been to express a permissible variation on every dimension given. The results obtained in the shop then depend upon the particular combination of dimensions used. Different organizations using different combinations could obtain radically different results.

The existence of a tolerance on a drawing acknowledges the fact that variations are inevitable in the physical dimensions of the product. Any dimension given without a tolerance should not be construed to denote an absolute size without error, but rather to indicate that the permissible variation for that point or surface is controlled by tolerances given on other co-related dimensions, or that no attempt had been made to determine its permissible variation.

In making component drawings, the effort should be made to give the dimensions and necessary tolerances so that it would be possible to lay out one—and only one—representation of the "maximum metal" condition, and one—and only one—of the "minimum metal" condition. If such layouts were superimposed, the difference between them should represent a permissible variation on every surface. Any condition of the product which fell within the zone thus established could be considered as meeting the requirements of the drawing. If one were to make a few such layouts, it would soon be clear that there are always certain dimensions that should be given without tolerances if drawings are to be kept consistent and intelligible.

It must be realized at the start that it is impossible to give in every case on one component drawing all the dimensions that may be needed to construct the patterns, tools, gages, and other manufacturing equipment, without introducing many inconsistencies. Certain dimensions might be correct if one set of holding points and one series of operations were to be used, but might be incorrect under different conditions. If the component drawings are made so that they represent the proper completed conditions, the end in view is attained. Any figures that the shop desires to use are correct if they insure this result.

After production is well under way, the component drawings have served their first purpose. In the meantime, the actual manufacturing operations have made available a store of new information regarding the actual conditions that should be maintained. It should be the second function of component drawings to record as much of this information as possible. Conflicting information, or misinformation, should be eliminated at the same time; in short, the drawings should be revised to agree with actual conditions and requirements.

Principles for Proper Dimensions on Component Drawings

The problem of the proper dimensioning of component drawings is strictly a mathematical one. There are a few basic principles in regard to it as fixed and simple as Newton's laws of motion, but even more difficult at times to apply correctly. When either of the two following principles is violated, trouble is inevitable:

1. There is but one dimension in the same straight line that can be controlled within fixed tolerances. That is the distance between the cutting surface of the tool and the locating or registering surface of the part being machined. Hence, it is incorrect to locate any point or surface from more than one point in the same straight line.

2. Dimensions should be given between those points which it is essential to hold in a specific relation to each other. This applies particularly to those surfaces in each plane which control the positions of operating parts. Many dimensions are relatively unimportant in this respect. It is good practice for such cases to establish a common location point in each plane and give, as far as possible, all such dimensions from these common location points.

There are also a few other general principles which it is good practice to follow. Although violations of them are not errors in themselves, they lead to many unnecessary errors. In all of this work it must be realized that it is impossible to create anything that is altogether "fool-proof"; the best that can be expected is to make conditions such that little or no excuse remains for making a mistake. The three following principles are of this order:

1. The basic dimensions given on component drawings should be those which would be used if it were possible to work without tolerances. The direct comparison of the basic sizes of mating parts should check the "danger zone." These sizes are the most important as they control the interchangeability. They should be the first determined, and, only established, they should remain fixed if the mechanism functions properly and the design is unchanged. A study of the conditions will show that a variation from these sizes in one direction is usually more dangerous than a variation in the other. For example, on operating parts the fits can be looser but not tighter. The direction of the tolerances should be in the less dangerous direction. If a variation from a fixed size in either direction is equally dangerous, as often occurs in the case of the locations of holes, the tolerance should be an equal amount in both directions. In the majority of cases, however, the tolerances will be in one direction only.

2. Dimensions should not be duplicated between the same points. The duplication of dimensions causes much needless trouble due to changes being made in one place and not in the other. It causes less trouble to search a drawing to find dimensions than it does to have them duplicated and inconsistent, although more readily found.

3. As far as possible, similar dimensions on mating parts should be given from the same relative locations. This procedure assists in detecting interferences and other improper conditions.

If careful thought is given to these component drawings, much time and effort will be saved in the shop. If they are neglected, all the future work will suffer because of such neglect. When a product is made in a single manufacturing plant, it is possible to maintain close contact between the designing and production departments. Yet even here, incomplete or ambiguous component drawings cause much delay and expense. If the production is distributed among a large number of plants, as is the case when war munitions are required in quantity, such neglect of component drawings will cause far greater delays and expense. In all events, steps should be taken to keep those responsible for the design in close and constant touch with the production so as to correct at the earliest possible moment any omissions, incomplete or indefinite specifications, and errors that always become apparent after production is under way.

Gages

There are two important reasons for inspecting the product during manufacture: First, spoiled parts should be eliminated as soon as possible to save the expenditure of useless effort on unserviceable pieces; Second, the completed components should be checked before assembly to eliminate any unserviceable parts that may have been completed, and to insure the proper functioning of the mechanism. For these purposes, gages are extensively employed.

There are two kinds of gages to consider, which, for want of better terms, will be called limit gages and functional gages. A limit gage is one which checks a specified surface to specified limits of size. A functional gage is one which checks the relationship of several dimensions to insure the proper functioning of the assembled mechanism. As with other manufacturing equipment, the exact design of a gage is unimportant as long as it fulfills its purpose simply and efficiently.

The degree of accuracy required on a gage depends upon the extent of the tolerances. In all cases, on limit gages, any variations must be within the established limits of the component. The dimensions given on component drawings are limit gage sizes. For example, the limits given for a diameter of a stud should be interpreted to mean that such diameter must be made to satisfy ring or snap gages of the sizes specified.

Tools and Equipment

Suitable tools and equipment with which to manufacture the product must be provided. The logical first step to this end is to make operation lists, planning in detail the successive operations, and specifying the type of machine, fixture, tool, and gage required. Of the machines themselves, but little mention need be made. Standard machine tools are now on the market for making almost every variety of machining cut. Special machines are required only for very unusual operations or for extremely large productions, where many automatic operations are performed.

The design of the fixture and the tool depends to a great extent upon the design of the piece to be machined. Great care should be taken to maintain the same locating or registering points in the fixtures as are used for the gages. The ideal condition is to have the registering points for both fixtures and gages identical with the points on the component drawings from which the surfaces in question are dimensioned. After the equipment is completed, the component drawings should be

checked and revised where necessary to obtain this result.

The actual production consists of taking the raw material and passing it through the equipment until it emerges as a finished component. The production problems are many and varied. Any part of the preceding work which has been slighted or left undone must be completed here in addition to the many other tasks involved in the production itself.

The present tendency is to subdivide the productive operations into simple and elementary tasks so that operators can be quickly trained to perform them. The less skill required of the operator, however, the more elaborate and complete the manufacturing equipment must be. In addition, the amount of supervision required for both operators and equipment is also greatly increased, both in quantity and quality.

In any case, the better the training that these operators receive, the higher the quality of the work produced. The operator should be taught to maintain the established tolerances. If the specified tolerances prove too severe in practice for economical production, they should be corrected, provided the functional requirements of the mechanism will permit. If they are not too severe, there is no excuse for violating them. The practice of adhering to the specified tolerances will do much to promote a high quality of product.

Inspection

The inspection and acceptance or rejection of the components falls logically into two divisions. The first is the shop inspection which is made while the material is in process of manufacture. The object is to cull out defective work as soon as possible and also to detect any defects in the equipment that would result in faulty work.

The second division of the inspection is the final examination of the completed parts. The object of this inspection is to see that all finished components which will function properly are accepted and that all unserviceable parts are rejected. This inspection is largely governed by the requirements of the component drawings—often represented by gages—and by specifications. It is therefore most important that the drawings and specifications give as nearly as possible the limits of parts which will function properly. Yet, as has been already noted, these drawings and specifications are incomplete at the beginning, and probably will always be so to a certain extent. Therefore a rigid adherence to the letter but not to the spirit of the drawings and specifications is unwise, as it will not aid in the acceptance of all serviceable material. In addition to the written requirements, inspectors must have a certain amount of education and experience with the mechanisms involved, or with similar mechanisms; otherwise the inspection will always prove a hindrance to the main purpose.

The spirit of the requirements should be enforced in those cases where their exact expression is incomplete. If the essentials are always specified definitely and completely, it will be a fair assumption that incompletely specified conditions are relatively unimportant. Wherever possible the requirements should be revised to make the letter and the spirit agree, but the attempt to cover every minute and unimportant detail may prove impossible in practice.

The functional requirements should be maintained in the final inspection strictly according to the specified conditions. The non-functional requirements should be handled in a more judicial manner, each case being decided on its merits. As a matter of fact, this final inspection should be in the nature of a functional inspection only. Little attention should be given here to the non-essentials other than, perhaps, a visual inspection for general quality, and some supervision of the shop inspection to see that proper precautions are taken during production to insure a good product. In all cases, the main effort throughout the work should be to establish, define, and maintain the essential conditions first, letting the non-essentials develop in practice. No secret, however, should be made of the fact that these non-essentials are left to work out their own salvation.

The final and complete evidence as to whether the aim has been accomplished is furnished after the mechanisms have been assembled and tested in service. If the total costs have been reasonable and the completed mechanisms assemble properly and perform satisfactorily all the required functions, it is conclusive evidence that all essentials have been mastered. On the other hand, if the costs are excessive or if the mechanism fails to assemble or operate properly after being assembled, it is equally conclusive evidence of failure.

Importance of Minor Details in Interchangeable Manufacture

The foregoing is a brief synopsis of the elements of interchangeable manufacturing. Success is only attained by careful attention to innumerable petty details. No single problem connected with it is very difficult of solution. It is the great mass of detail that makes it perplexing.

Great as is this mass of detail under ordinary conditions, it is far greater in the production of war munitions in an emergency. The great volume of production required, the distribution of the work among a large number of separated plants with the resultant loss of intimate contact between the designing and producing departments, together with the necessity of producing commodities whose manufacturing designs have not had the acid test of actual quantity production, all go to increase the mass of detail to be attended to constantly.

There are, however, certain precautionary measures that can be taken in advance which will be of great aid in an emergency, and which will promote the prompt start of production. Several of these will be discussed in the following paragraphs.

One of the greatest possible causes of delay is the provision of special manufacturing equipment such as special fixtures, cutting tools and gages. Some of this can be overcome by using, in the manufacturing design, as many widely used commercial standard parts and elements as possible. Quite complete standards for screw threads, cylindrical fits, and other elements have been promulgated by various standardizing bodies. The use of these standards will make available in time of need a large stock of tools and gages already existing in the various manufacturing plants.

Another factor in the manufacturing design should be to design the surfaces of the various parts so that, as far as possible, they can be machined readily on standard machine tools. Only in exceptional cases should it be necessary to use special machines for machining any surface.

The detailed component drawings themselves must be made and dimensioned with even greater care than is required under ordinary circumstances, where close contact exists between the designing and producing de-

partments. Nothing should be left undone to make them clear, complete, and definite. Laws of dimensioning have been given in the preceding pages which, if followed carefully, will promote this result.

Methods of Expressing Dimensions and Tolerances

The method of expressing the dimensions and tolerances should be carefully considered, and that method which best suits the particular purpose should be used. In general practice today there are three good methods of expressing tolerances, which are widely used. Each has a particular field for which it is best suited.

One method is to give the limiting dimensions in full as follows:

$$\text{Hole}\begin{cases}1.500\\1.503\end{cases}$$

$$\text{Shaft}\begin{cases}1.498\\1.495\end{cases}$$

This method is most widely used where the control of the sizes of the parts in production is entirely by gages. This most generally exists where the rate of production is large, and the sizes of the components are small, such as in the manufacture of typewriters, sewing machines, talking-machines, small arms, artillery ammunition, etc. In this case, the shop itself makes little use directly of the component drawings. The limiting sizes give directly the sizes of the gages, and prove as useful as any other figures for establishing the sizes of fixtures and tools.

A second method is to give the "maximum metal" sizes followed by the tolerance, as follows:

$$\text{Hole}\begin{cases}1.500\ {}^{+\ .003}_{-\ .000}\end{cases}$$

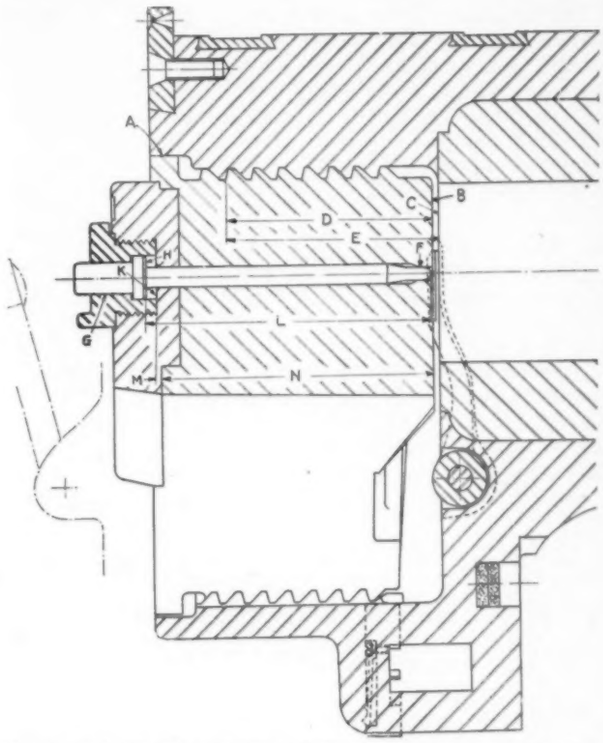
$$\text{Shaft}\begin{cases}1.498\ {}^{+\ .000}_{-\ .003}\end{cases}$$

This method is most widely followed where the control of the sizes of the parts in production is partly by standard measuring tools, and where on many operations the accuracy of the results obtained depends to a greater or lesser extent upon the skill of the operator. This generally exists where the rate of production is moderate, and where the sizes of many of the components are reasonably large, such as in the manufacture of medium sized machine tools, some automobiles, aircraft engines, field artillery, etc. In such cases, the existence of a definite dimension gives a more definite target to shoot at, while the tolerance shows the permissible direction and amount of variation.

The third method uses common fractions as far as possible followed by figures indicating both the tolerance and allowance, as follows:

$$\text{Hole: } 1\tfrac{1}{2}{}^{+\ .003}_{+\ .000} \qquad \text{Shaft: } 1\tfrac{1}{2}{}^{-\ .002.}_{-\ .005}$$

This method is widely followed where the components produced is almost entirely by the use of standard measare very large and the control of the sizes of the parts uring tools. In such cases, the roughing operations are often controlled by the use of steel scales, calipers, tapes, etc., and the use of decimals is dangerous. At the finishing operations, where more sensitive measuring instruments are employed, it is as easy to read a definite number of thousandths under a given nominal size as it is to read the decimal dimension directly. These conditions exist in the production of large machine tools, locomotives, large guns, caissons, gun mounts, etc.



Diagrammatic Sketch of the Breech Mechanism of the 75-mm. Gun

In all of the above cases, the examples given express identical conditions.

War Time Production of Munitions

Ordinarily, a manufacturing design is tested by actual production, where time, although important, is not essential. This, however, is seldom if ever possible with munitions in war time. The design should be thoroughly tested as to its functional ability, but the quantity of production is rarely great enough to test all the manufacturing features thoroughly until the moment of emergency arrives, when time is essential. One possible substitute for this manufacturing test is to submit the component drawings to various manufacturing organizations, who would be called upon in time of need to produce them, for their criticism; not of the construction, but as to their manufacturing qualities. Commercial manufacturing plants themselves have not yet reached a state of perfection, and many of the criticisms received would reflect but personal opinions and be valueless as guides. Nevertheless, the practice would prove an educational one in many respects for all parties. For one thing, it would give the commercial manufacturing organizations a valuable familiarity with the material in question and many valuable suggestions would undoubtedly come from them. It would also tend to make apparent any obscure or incomplete information that persisted.

As an example of some points which have been discussed, we will consider a few features of the breech mechanism of the 75-mm. gun. The preceding figure shows a section of the breech mechanism. Considering the breech block first, this must be located in three planes. The threads and the cylindrical surface A locate its position in two planes, while the position or qualification of the threads rear side locates its position in the third plane. In its operating position, the forward face

B of the breech block must maintain its relative position to the rear end of the tube C. In addition, the angular position of the breech block must be maintained in order to hold the firing pin central with the bore of the gun. This is accomplished by a stop on the breech block arm not shown in this section. Once these surfaces are located and defined, all other surfaces should have liberal clearances, and be located from convenient working points. The dimensioning of the diameters offers no difficulties. To locate the position of the threads, an arbitrary common point of the thread on both members is selected, and this arbitrary point is located from the essential surfaces B and C by the dimensions D and E.

Considering next the firing pin, this is located on the cylindrical surfaces F and G, while its firing position is controlled by the surfaces, H and K. The position of the surface H from the point of the firing pin is controlled by the dimensions L, and the position of surface H from the front face of the breech block is controlled by dimensions M and N. All other surfaces on the firing pin should have liberal clearances and be located from the most convenient working points.

This gives two definite examples of the principle that dimensions should be given between those surfaces which it is essential to hold in a specific relationship with each other. The importance of carrying out this principle cannot be too strongly emphasized. Neglect of it inevitably leads to trouble.

Successful interchangeable manufacturing is only accomplished by the solution of innumerable petty problems. This can only be attained by unremitting attention to detail and close cooperation between all parties involved—designers, producers, inspectors, and, too, the users of the finished commodities. Under such conditions, remarkable results can be accomplished. Without these conditions, we will just muddle along and the quantity production of munitions will be the loser.

Metal Specifications for Ordnance Materiel

AS an incident to industrial preparedness, the Ordnance Department has for several years been engaged in the revision of existing specifications and the preparation of new specifications, placing particular stress on specifications of articles for issue to the Service and raw materials used in their manufacture. The metal specifications are now practically complete, and they have been distributed from time to time as issued.

Each metal specification includes this paragraph:

"General Specifications for Metals and Metal Products, No. 57-O, issued by the Ordnance Department, in effect at the date of opening of bids, shall form part of this specification."

The General Specifications have been approved, printed and distributed, and instructions have been issued to put the new specifications into effect as of April 1, 1924, for procurements and for designating material on Ordnance drawings.

The General Specifications for Metals and Metal Products contains this paragraph:

"For Ordnance Department drawings bearing original date prior to April 1, 1924, which prescribe metals in accordance with old specifications, a "Conversion Table," drawing 27-75-1, 2, etc., is provided, which shows for each metal specified in accordance with old specifications the appropriate replacing metal in accordance with this and related specifications which will be substituted therefor. The use of the replacing metals called for on the "Conversion Table" in the column headed "For Purchase Replace With," is mandatory on all procuring and manufacturing agencies of the Ordnance Department, and on all contractors working from Ordnance Department drawings of original date prior to April 1, 1924."

The Conversion Chart consists of six large drawings and is intended to indicate what material should be used in current manufacture when drawings dated prior to April 1, 1924, are used. The preferable method would, of course, be to revise all such drawings so as to show the material in accordance with the new specifications, but, in view of the very great number of such drawings, the cost of revising them would be prohibitive. It has even been found that the cost of making Conversion Charts which would be complete would be too great to warrant so doing; consequently, alternative materials are provided by the Chart in a number of instances. Each sheet of the Conversion Chart bears the following notation:

"When the Conversion Table indicates replacements by the remarks 'See Grades Provided' or 'See Tempers Provided' or where an alternative is provided, the contract or purchase order will ordinarily specify the particular metal to be used in each case. Otherwise, the Inspector will specify which alternative will be used."

It is to be assumed that in making procurements under these specifications the question of substitutions will have to be considered at the time of placing the order, and that the order must specify the material to be used for various components in important cases. This matter should be left to the discretion of the inspector only in unimportant cases.

Existing drawings dated prior to April 1, 1924, will gradually be revised or become obsolete, so as time passes the use to which the Conversion Chart is put will greatly diminish. It is hoped eventually to have the Conversion Chart printed as a part of the General Specifications for Metals, but it seemed probable that this chart would be subject to considerable revision in the first year of its use, consequently it is published as a series of drawings which are more easily revised than a printed specification.

A new Index to Metal Specifications, dated April 1, 1924, is being published.

Many detail specifications contain requirements which are common to a number of materials or articles. The American Society for Testing Materials has taken the attitude that each specification should be complete in itself, and this, of course, leads to a great deal of repetition in closely related specifications. The Ordnance Department in approving and publishing General Specifications for Metals and Metal Products has adopted the principle that it is fundamentally wrong to make the same provisions in more than one place, and that no provision should appear in a subordinate specification which is of more general application than the specification itself. Where the same provision appears in more than one place there is probability of serious error.

Gaging the Springfield Rifle

By

EARL McFARLAND

IT is a far cry from a wine cask to a Springfield Rifle. And yet the line of ancestry is complete and quite direct, for the first gage appears to have been the standard measure of a wine cask. From this satisfactory old standard of measure, gages have developed in successive generations down to our own, and the Springfield Rifle is so dependent upon this development that it is quite impossible, from the manufacturing view point, to think of the rifle without at the same time linking with this thought a picture of the evolution of the gages so essential to its production.

Major McFarland

The conception of interchangeable manufacture seems to have originated from the necessity of replacing broken and damaged parts of mutilated rifles on the battlefield. From this origin has grown up the enormous field of interchangeable production followed in all lines of manufacture, but now not so much as a means of the replacement of parts as a means of mass production. The manufacture of components on this basis requires proper machine tools, jigs, and fixtures, and above all a system of gaging and inspection that will insure correct location of the intermediate operations for bedding points, and the interchangeability of finished components. The art of interchangeable manufacture received a very great contribution on the part of one Captain John H. Hall,[1] who in 1825 was manufacturing rifles for the United States Government at the Harpers Ferry Armory. In a communication to the Secretary of War in 1827, the Chief of Ordnance, referring to the methods of manufacture used by Captain Hall, stated that: "The machinery used in the fabrication of these rifles has been constructed upon a new and improved plan, by which a very important improvement in the fabrication of fire arms has been effected. By the aid of this machinery, each of the various separate parts which, when united, forms one arm, are constructed in that perfectly accurate and uniform manner that any one of the parts of one arm will fit exactly the corresponding part of any other arm of similar model. And this perfection is accomplished at a less expense than is occasioned by the use of the ordinary machinery in executing work in the usual and less perfect manner. * * * "The machinery constructed for, and used in fabricating Hall's rifles, executes the work with such exactness that the component parts of one hundred rifles made some years past have been joined to other parts made recently without the least difficulty; all the parts fitting as exactly as if each had been separately adjusted to the particular rifle thus formed from the scattered members."

From the old muskets of these days, and from the methods employed by Captain Hall of Harpers Ferry and eventually adopted by the Armory at Springfield, have evolved the present day types of military arm and the methods of manufacture employed in their fabrication. The Springfield Rifle, generally referred to by this name but more properly known as the U. S. Rifle, Caliber .30, Model of 1903, was adopted for the United States Army as a result of a long series of tests and development work carried out at the Springfield Armory. Prior to the adoption of the Springfield, the Army had been equipped with a .30 caliber rifle known as the "Krag-Jorgensen." The new rifle was planned to meet improvements in the art of fire arms design and manufacture, and to keep pace with the arms of other nations. The work on the Model of 1903 Rifle was so well performed that this arm still stands as the supreme military weapon of the world. Since starting its manufacture very few changes have been made, other than in the type of sight and bayonet. The operating parts of the rifle have continued with practically no change in design, but of late years the greater requirements for accuracy in target firing and training have imposed very severe restrictions on the latitude allowed in the manufacture of the piece, and while the gages have not been changed, the inspectors have been instructed to hold very closely on certain points.

The system of gaging the Springfield Rifle is the outgrowth of the gage methods used for its predecessor, the Krag-Jorgensen. The Krag gages were in turn developed

[1] "Captain John H. Hall: His Contribution to the Art of Arms," by Colonel T. L. Ames, ARMY ORDNANCE, Vol. III, No. 18, May-June, 1923.

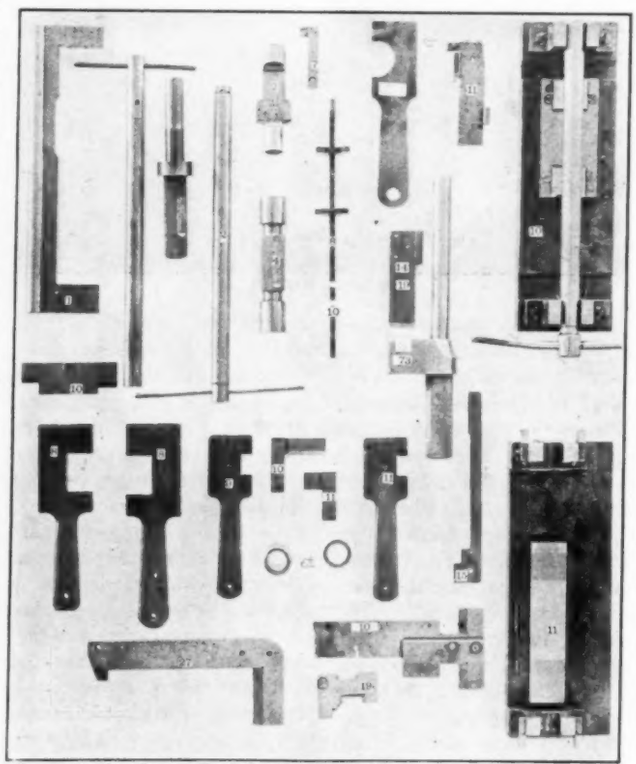
The Springfield Rifle, Caliber .30, Model 1903

from the older 1873 and 1884 Models of the Springfield Rifle, although these earlier rifles were of very different operation and type. In many cases old gages, in the interest of economy, were used by the necessary modification for the newer models of rifles, and the system of gages thus built up represents an evolution rather than a complete and systematic set of gages designed in accordance with the most enlightened technical and engineering view point. It can almost be said that the first set of gages used in the manufacture of the Springfield Rifle allowed no tolerances whatever, all of the gages having been manufactured in accordance with a flat dimension. It is obvious, and was obvious, that it is impossible to manufacture without some allowance or leeway in dimension on account of inaccuracies in the machine, the tools, and the hand of the operator. With the earliest system of gages in vogue, it is therefore apparent that the inspector literally carried the tolerances "under his hat." In other words, the inspectors had been in the employment of the Springfield Armory and had been doing this particular kind of work for such a long period of years, that they knew from the amount of light showing between the gages and the work, whether or not the work would be satisfactory for the purpose for which intended. The satisfactory operation of a system of this character is based entirely upon the knowledge of the inspectors and not upon the sufficiency of the gages. Such a system is incompatible with mass production or with changing personnel.

Shortly after the outbreak of the World War in 1914, large orders for munitions were given to manufacturers of this country and the production of war supplies was, for a time, the most important product of our metal working plants. Production in quantity was the keynote, and it became more and more evident as the weeks went by that production in quantity meant interchangeable manufacture, which in turn, depended finally upon proper gaging methods as a means of determining the degree or satisfactoriness of interchangeability. This condition brought more forcibly to the attention of the authorities at Springfield Armory, the fact, already well known to them, that the system of gaging employed at their establishment required revamping in order to be satisfactory for use by outside concerns, should it ever be desired to give orders for the Springfield Rifle to commercial plants. They realized the need of a change should there be a demand, and for high production of rifles at the Armory under any enlarged program requiring additional operators, additional inspectors, and a large turnover of labor.

After considerable time spent in investigation, a contract was given to the Greenfield Tap & Die Corporation in April of 1917 to perform the following work: (a) To determine accurately all tolerances in dimensions of parts of the Springfield Rifle as then being manufactured, (b) To design a complete set of working gages for the rifle in accordance with (a), (c) To design and manufacture master gages to provide quick and accurate means of checking the accuracy of all the working gages determined under (b).

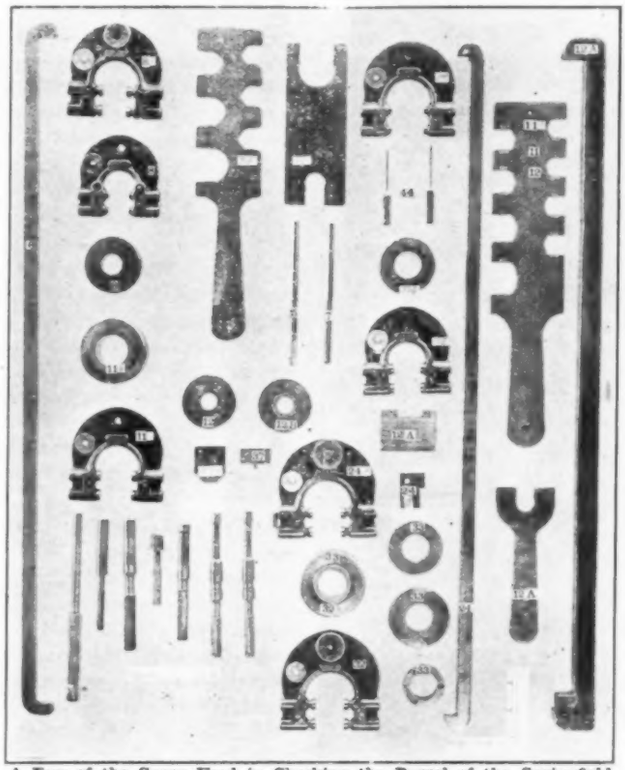
The work undertaken by the Greenfield Tap & Die Corporation was delayed on account of war contracts, and as the Springfield Armory was satisfactorily producing under the old system it was considered inadvisable to make radical changes during a time when steady production was essential. The completion of the Greenfield Tap & Die Corporation contract was therefore delayed until after the close of the war, and Springfield Armory carried on under the old system of gaging and inspection. It is of interest to note that the Springfield Rifles used for the National Matches of 1919 were war production rifles particularly selected as to dimensions of barrels. That these rifles gave satisfactory performance in the hands of the most expert shots of the country may almost be taken as a vindication of the old gaging system. At least it shows that with conscientious care and competent supervision, accurately made materials can be turned out in spite of some defects in gaging equipment.



Some of the Gages Used in the Inspection of the Receiver of the Springfield Rifle

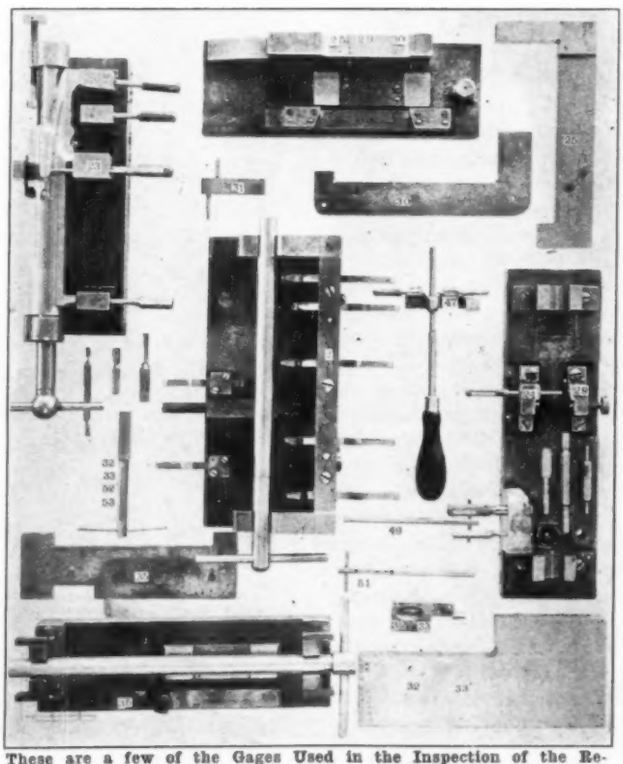
If the benefits of the

Greenfield Tap & Die contract were to be immediately realized by the Springfield Armory it would require that the system of gages that had long been in use at the Armory be immediately discontinued and that new gages built in accordance with the Greenfield Tap & Die gage drawings be substituted therefor. The expense involved in such a scheme would be very great. It was accordingly decided that the old gages would be continued on the job but that individual gages of the old type would be replaced by gages of the new type as soon as such old gages began to show wear or deterioration. The practical result is that there are now in the shops at Springfield gages of both the old and the new design, the old gages being by far in greater number. It is expected that this process of replacement will be continued so that eventually and without any great expenditure of funds at one time, the Greenfield Tap & Die working and inspection gages will replace all of the old type of gages formerly used. The master reference gages for checking the newer gages are already on hand. The gaging system for the Springfield Armory will then be entirely modern and up to date.



A Few of the Gages Used in Checking the Barrel of the Springfield Rifle

In order that the practical side of gaging the Springfield Rifle may to some extent be understood by those interested, illustrations are shown giving all of the gages used in the inspection of the receiver. The receiver is by far the most important single component of the rifle and is really the heart, the vital organ, of the arm. This is the piece to which the barrel is attached and around which the entire mechanism and outline of the gun are built. The small numbers on the gages designate the operation numbers to which the particular gages pertain. A total of seventy-eight operations on this component are gaged.

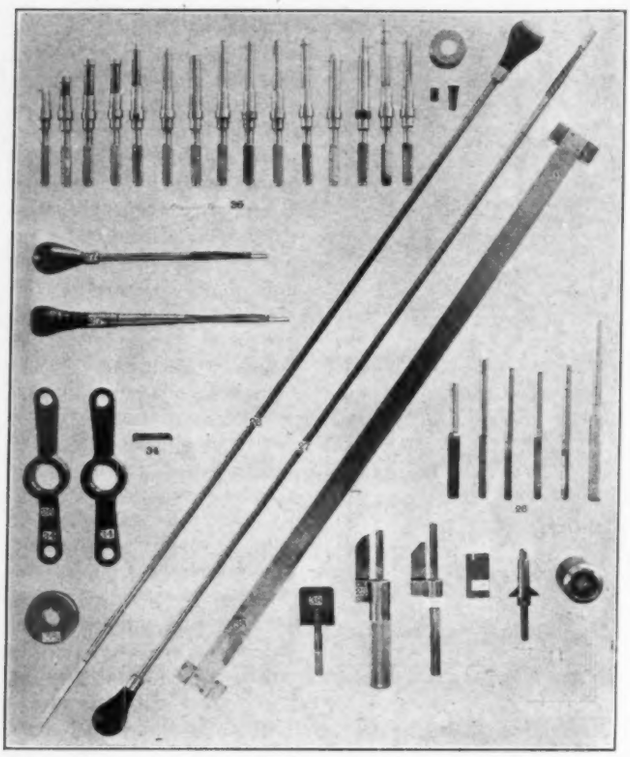


These are a few of the Gages Used in the Inspection of the Receiver for the Springfield Rifle

Among the more interesting of the gaging operations may be mentioned Operation 1 for length, and Operations 3 and 6 for size. It will be observed that the gaging of holes is always held up until after the hole is reamed, even when the hole itself is used as a holding or working point. Operations 9 and 11 consist in milling the right side square, so that this side may thereafter be used as a working, holding and gaging point in future operations. The square lugs now milled are eventually entirely removed. The practice of using bedding and gaging points that are removed frequently leads into difficulties in that it may remove the only reference points for important operations, and make it impossible to later check the accuracy of the work. In the case in point, the lower right wall of the receiver is milled at the same time as the square lugs. The distance between the two is gaged for height. The draw-line is located from the right wall. The standards established by the two square lugs are thus definitely transferred to another part of the piece. And though these lugs are removed, accurate gaging of all parts of the finished receiver may still be made. The draw-line becomes a very essential gage and assembling mark and is put on in Operation 17.

The gages shown under Operations 14, 21 and 22 illustrate types of form or contour gages only, for air fits and unimportant points. Operation 15 uses a block gage to check the location and contour of the milling operation under the cut-off. All of these block gages are fitted with adjustable stops against which the piece must be brought before gaging. Operation 17, establishing the draw-line, is gaged by a bore gage with side to come up against the lower, milled right side of receiver. A line is placed on the periphery of the gage. The draw-line as established on the receiver must

coincide with the line on the gage. This draw-line is used as a gage mark to determine the accuracy of starting the barrel thread in receiver, the location of the



These Gages Are Among Those Required in Checking Exterior Dimensions, Threads, Chamber, Bore, and Grooves of the Barrel of the Springfield Rifle

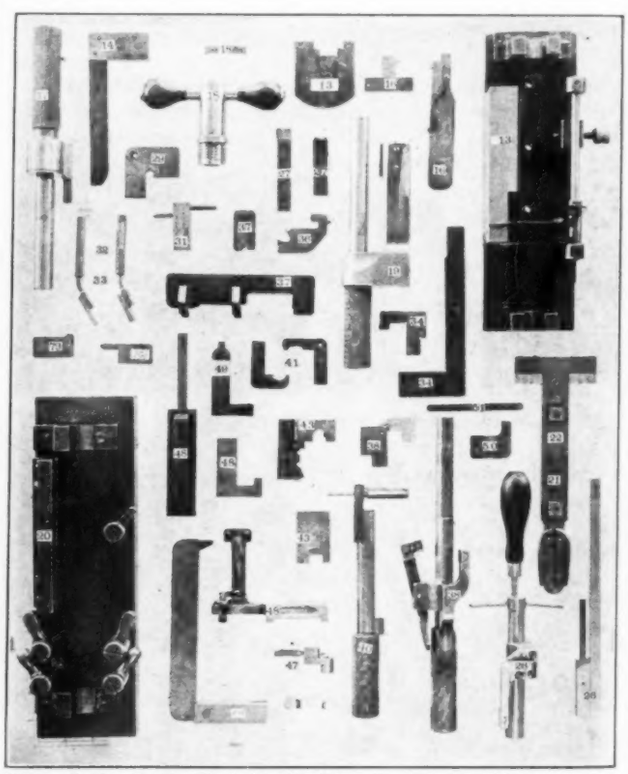
barrel axially, which in turn locates the position of the front and rear sights. This line is of extreme importance.

Operation 20, milling the underside of the tang, employs a block gage with revolving fingers. The receiver is located on an arbor, upside down so that the right side squares locate it against the gage stops. The fingers gage the locations of tang for center. The gaging fixture for Operation 23 presents an interesting type. The receiver rests on an arbor passing through the well hole and rolls on to the right front lug stop. Plugs pass in two guard screw holes, the ejector pin hole, the sear nose and rear of magazine guide holes. (Sear nose and magazine guide holes are for machining only and are later removed.) Plug gages for depth and size of guard screw holes are also used.

Operations 49 and 51, rough and finish milling the cocking piece groove, are gaged for width and depth of groove by the block gage shown, the finger locating the position from the right hand wall of the receiver. Operation 56 finishes the total length of the component, and is measured by a vertical gage, the receiver fitting on one vertical arbor and the measuring edge on the other. Operation 59, the sear nose slot, uses a peculiar distance gage. It is to be observed that where the firing, trigger and sear mechanisms come into play, the front of the receiver is the gage point. This obviously connects the firing mechanism directly with the barrel chamber, which determines the cartridge location.

And so the gaging operations continue for practically every cut of the receiver. The main lines of gaging in this very complicated piece, consisting of about 100 operations, are: (a) From the front end of the receiver which is the basis for all longitudinal dimensions, (b) From the right side square lugs for all lateral dimensions until operations 73 and 74 when these lugs are removed. The right side bottom wall is then the standard reference surface. (c) The very important splining cuts for the bolt lugs are gaged from the bottom of the receiver as is also the sear cut. (d) The well hole is used in conjunction with (a), (b) and (c), and ties in with them.

Next in importance to the receiver is the barrel, and the entire firing accuracy and life of the weapon is dependent on this one component. The standard of workmanship is held rigidly to gage and nothing is accepted which would diminish the accuracy of the barrel. This component causes more concern than any other part of the rifle. The barrel blanks are received already forged, rolled and heat treated. Gaging follows the machine operations with the same care as is exercised in the receiver. The main lines of gaging in the barrel are: (a) From the butt end which is milled off in the first machining operation. This original cut is practically the final one. (b) From the draw-line, which determines the position of the spline and in turn the front and rear sights. (c) The draw-line is covered up by the fixed base, but the left shoulder of the fixed base is seated directly over the draw-line and actually becomes a new draw-line. In assembling to the receiver the draw-line establishes the position of the barrel and sights in relation to the receiver, which has been provided with its

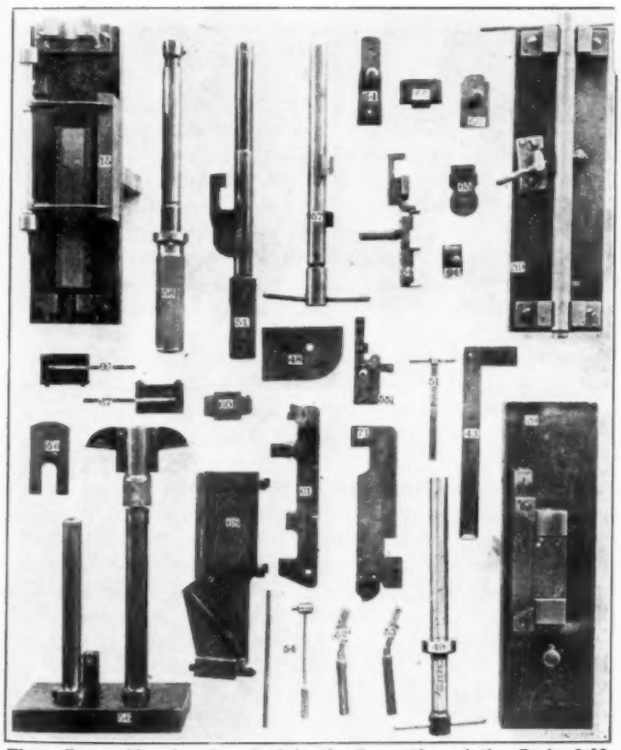


More of the Gages Used in Checking the 78 Operations in the Fabrication of the Receiver of the Springfield Rifle

own draw-line as previously mentioned. This links up the very complicated receiver cuts to the barrel. (d) The interior dimensions are carefully gaged by special gages, and, when required, by the star gage.

It may be of interest to examine more particularly

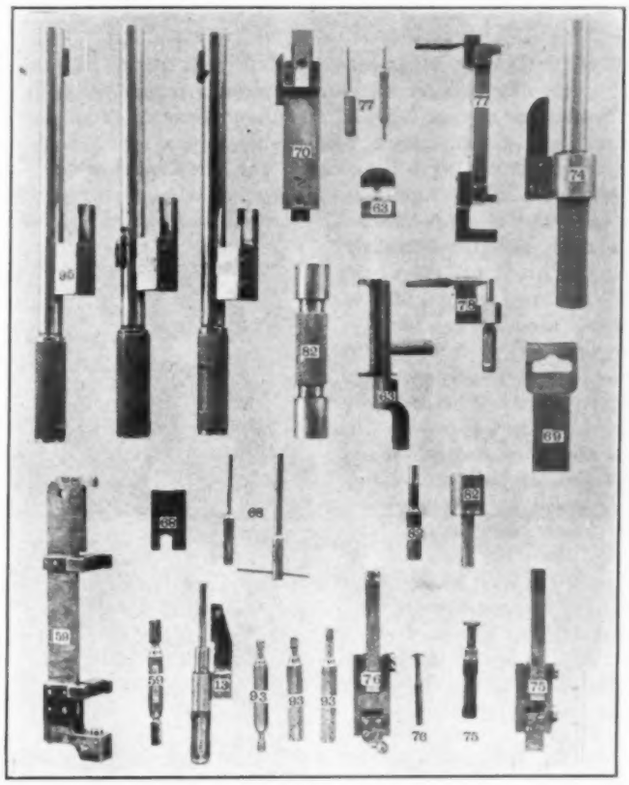
the use of the gages required in Operation 36, that is, finishing the chamber to final dimensions. The gages used are depth, diameter and taper gages and do not verify the angle of the shoulders. This is actually checked in the proof firing of each rifle by observing the fired cartridge case for irregularities. In using the chamber gages, the collar shown is set on rear end of the barrel. The gages are then dropped into the chamber and a straight edge used to determine whether or not the shoulder of each cut is of proper depth. The first shoulder gage is covered with red-lead to see that the first shoulder angle is of proper contour. A short-angle gage is also used so that the angular inclination is partially checked. Because each section of the chamber is tapered, the gages are made of different lengths and the diameter of the chamber at various intervals is accordingly verified by the depth to which the gage goes. There are 15 finish chamber gages in addition to the cap or collar. The 1st four gage the diameter at mouth and at intervals to the first shoulder. The 5th and 6th gage for depth of first shoulder. The 7th and 8th gage diameter of rear end of neck, maximum and minimum. The 9th and 10th gage diameter of front end of neck, maximum and minimum. The 11th measures the taper all the way in the neck. The 12th is a distance gage, from collar to second shoulder, i. e., the forward end of neck. The 13th is a taper gage for the bullet seat, maximum and minimum. The 14th hits all the points and provides .003" tolerance from collar to bullet seat. The 15th is a straight gage, length to forward end of neck.



These Gages Also Are Required in the Inspection of the Springfield Rifle Receiver

The gages shown illustrate the general type of gage used and will not be described in detail.

The most obvious conclusion to be drawn from an observation of the gaging method at Springfield Armory is that it is complete and thorough, and covers practically every machine operation of each component. Yet it must be said that the system is not more comprehensive than required to accomplish its purpose, that is, to



Part of the 193 Gages Required to Check the Operations of the Receiver of the Springfield Rifle

produce on a quantity basis a rifle that is entirely interchangeable and of very superior quality.

The investigation of a complicated system of gaging such as that for the Springfield Rifle is most absorbing and becomes a fascinating study.

That the pioneer work of such men as Captain John H. Hall, and his precursors Whitney and Morse, as outlined by Colonel Tilson in his article on page 353 of this journal, has been productive of far-reaching results is at once evident from the application of their work to this one piece of Ordnance equipment, the Springfield Rifle. What has been said regarding it is equally true of every other piece of matériel—some in a greater and some in a less degree. The manufacture of the Springfield, the Browning, the 75-mm. Gun, an artillery ammunition fuze—and every item of the hundreds that are comprised in the term "ordnance"—emphasizes not only the importance of gages to the quantity production of munitions but also the absolute interdependence of the two. If we must have munitions in quantity and on time then we must have gages accurately made, adequately dimensioned, and properly designed before we can attempt to produce arms and armament in quantity. What has been said here concerning the gaging of the Springfield Rifle should demonstrate this beyond reasonable doubt. The design and manufacture of ordnance is no mere child's play; it is a serious process that demands all the time and effort that industry and ordnance engineers can give to it. And in this process the design and manufacture of gages in time of peace for immediate availability in time of war ranks high in importance.

Under-Water Storage of Smokeless Powder

By FRED OLSEN

INFORMATION has been received from several sources that the subject of storing powder under water is receiving considerable attention abroad. The advantages of immersing nitrocellulose powder in cold mountain lakes were apparent. The constant low temperature conditions prevailing there could be expected to retard the decomposition of nitrocellulose which would normally take place in powders stored in magazines the average temperature of which would be considerably higher and in which there would undoubtedly be rather wide variations in temperature. It was hoped that by so doing the stability life of propellant powder might be increased by several years, a conservative estimate being that the life of the powder would be ten years longer than the average expectancy of fifteen years.

In addition to the advantage of prolonged stability, the very important advantage was indicated, namely, that the hazards would be very materially decreased. Dangers from fire or explosion would be eliminated and constant supervision of storage areas unnecessary.

Picatinny Lake, Picatinny Arsenal, Dover, N. J., Where Experiments in Under-Water Storage of Smokeless Powder Are Being Conducted

To offset these advantages it was recognized that the water might act on the powder in such a way as to reduce its solvent content, rendering the powder more brittle upon subsequent drying. This expected change in the volatile content of the powder might also be shown in impaired ballistic properties and possibly erratic velocities with occasional excessive pressures. However, the reports from abroad indicated that powder which had been in storage for several years could be given a simple drying treatment and fired in the gun for which it was originally designed without appreciable variation in the velocity or pressure, nor were the results markedly different when the powder was stored in sea water. The stability of the samples was not injured, and in the case of one sample of powder which had been immersed in sea water for several years the stability was even better than that of samples stored in surveillance magazines under presumably air-tight conditions. The results quoted in these reports were, however, entirely too meager to permit the drawing of definite conclusions, so that it was believed necessary to initiate a program at Picatinny Arsenal which would definitely show the advantages or disadvantages connected with under-water storage.

Powder of three widely varying granulations was selected, namely, for the 75-mm. gun, 155-mm. gun, and 12-inch gun, placed in specially prepared boxes provided with numerous openings to allow free circulation of water, and lowered into Picatinny Lake to a depth of at least three feet below the surface. An equal amount of powder was stored in a magazine in order that comparative tests could be made whenever samples were removed from the lake. A complete chemical and ballistic examination was made of the powder for the 75-mm. and 155-mm. guns and complete chemical examination made of the powder for the 12-inch gun. The powder at the beginning of the test was normal in every way. At the end of six months, samples were taken from the lake and subjected to the same tests that were made at the beginning of the program. No appreciable change had occurred in any of the samples. The stability as judged by the 135° Methyl Violet tests was somewhat better in the case of powder which had been placed under water, but small irregularities in this test are frequently encountered and it is not contended that these tests constitute evidence that the chemical stability has been improved. No variation in ballistic properties of the powders tested was observed.

These first tests indicated one point, namely, that little difficulty was to be anticipated in reconditioning these powders for use after storage under water. If subsequent tests corroborate this first result, which is admittedly obtained at a very early date, it will be an exceedingly simple operation to remove the powder from the water, wash in flowing water to remove silt or deposited organic matter, and finish the treatment with an air drying operation at 40° or 50° C. for a few hours.

Even if it should be shown that prolonged storage under water affects the reduction of the residual solvent to a point at which the powder becomes too brittle, it is quite probable that it would be more profitable to rework these stocks of powder than to prepare the powder anew from raw materials. It is further to be considered that in time of stress these stocks might constitute very valuable sources of the essential raw materials—cellulose and nitric acid.

In conclusion, it is believed that the under-water storage of smokeless powder offers many advantages, and the results to date are at least of favorable indication. The only difficulty which can be foreseen at the present time is the possible clogging of the minute perforations of the powder grains with organic matter, which will not be removed by any ordinary washing treatment. This, however, is not regarded as a very serious condition.

Ordnance Gage Design and the Industrial Engineer

By

E. C. PECK

IT has often been said that an Ordnance engineer requires a broader knowledge and training than an engineer in industry. This is probably due to the great amount of specialization in the engineering profession. This develops special experts on certain phases of engineering that require intensified study and research within well defined lines. This specialized field would not call for the full scope of knowledge necessary for an Ordnance engineer. On the other hand, a successful consulting engineer would require a knowledge and experience as broad as possible to cope with his various problems.

Colonel Peck

It is believed the basic requirements for good engineers are much the same, regardless of the particular field in which their services are required. Every first class engineer should have good analytical and creative ability, and above all things, accuracy.

It seems to me that the great difference between the engineer of industry and Ordnance is due primarily to the competition brought about by the disposition of their products. The engineer in industry has not only to produce a mechanism that will function properly, but he must create one simple enough to be built in competition with others, and at the same time net a profit to his associates in business. This should be the qualification of an Ordnance engineer also, but unfortunately it is not. This, however, is not the fault of the Ordnance engineer, but that of the system under which he works.

When the Ordnance engineer has completed a mechanism and it functions properly, he is practically through with it; whereas in the industries this stage represents the mechanism at a point at which the production and manufacturing engineers take it in charge and in conjunction with the designer, determine whether or not it is capable of being manufactured economically. With all interested parties conferring, the mechanism is corrected if necessary, so that it can be made on a quantity production basis without interfering with its functional requirements. Of course if the designing engineer, whether Ordnance or industrial, is also experienced in the modern manufacture of interchangeable parts, he has a great advantage over one who is not, because his designs will usually be capable of being manufactured economically.

One of the ways in which the Ordnance Department could obtain the experience of production engineers would be to amend the regulations so that Reserve Officers could spend the two weeks each year, required of them for service, in consultation. They could go to Washington or wherever necessary to confer with Ordnance engineers on the manufacturing practibility of their designs.

Many engineers in industry object to being Reserve Officers because they do not want to waste two weeks each year in camp somewhere, merely to meet the requirements of the regulations with no experience in their assigned work.

Importance of Tolerances

Those of us who were in the Ordnance Department in the past war are familiar with the many troubles that were experienced over the question of round hole tolerances and where the point of interference of metal was in relation to the basic standard. Some engineers wanted bilateral and some unilateral tolerances.

This was the place where the advice of a competent production engineer at the time that the designs were made would have saved unlimited time, trouble and money. This apparently minor feature of design, if not taken into account by the designer, may make the whole mechanism incapable of being made in quantity.

This failure to reckon with proper tolerances, thereby affecting the class of fit is quite natural because the designer is often chiefly more concerned with the proper functioning of the mechanism.

A great many engineers at some period of their experience find themselves responsible for specifying a certain character of fit. That is, they very often must be responsible for a set of dimensions on a drawing producing a kind of fit that will be suitable for the particular piece of work in hand. Many engineers have not had an opportunity to acquire a knowledge relating to the measurement of the clearance space that makes a familiar kind of fit. Hence it has often loaded them with an unfair responsibility because there was no reliable source from which to obtain this information. This lack of knowledge among engineers was plainly evident during the World War, as shown by evidence collected.

The writer used to ask prominent engineers, whenever opportunity occurred, to state in figures the minimum clearance space they would call for if they wanted a fit similar to the sample, the sample being a free moving ½-inch screw in a nut, and a free moving 1-inch shaft in a hole. The figures given varied from one-half of one-thousandth to five one-thousandths of an inch. That is, one thought it ought to be ten times as much as another.

There is no reason now why any engineer need to fear this responsibility, as the whole thing has been made easy for him by the work of the National Screw Thread Commission and the Plain Gage Committee. The progress reports of both of these committees are in process of approval by the American Engineering Standards Committee, having passed the sponsor bodies. In so far as the Army and Navy are concerned, the report of the National Screw Thread Commission has been approved for their use since 1920.

A study of the reports of the Screw Thread Commission and the Plain Gage Committee in detail will provide a liberal education for the engineer in regard to fits. While this study is urged, it is not absolutely necessary as familiarity with the tables and kind of fits by description is all that is necessary to dimension a drawing so that an engineer can be responsible for a fit that can be manufactured without the cost being prohibitive.

There is provided in the report of both the N. S. T. C. and the Plain Gage Committee, a system of classified fits, similarly numbered as to classes, and based on the fundamental that, "the interference of metal takes place at the basic size."

The minimum hole whether threaded or plain is always basic for the standard fits. The maximum internal member (screw or shaft) is basic or under basic size for all moving fits and always above basic for tight or force fits.

"Allowance" and "Tolerance" Distinguished

The terms "allowance" and "tolerance" should not be confused as regards mating parts. The allowance in a fit that moves is the minimum clearance between the mating surfaces. In a tight or force fit the allowance is the largest amount of interference in the metal necessary to produce the tightness desired. The allowance always represents the tightest permissible fit and is the ideal fit which the designer wants. This being true, the allowance must never be encroached upon by any variations in manufacture. The allowance always represents the condition of the largest internal member mated with the smallest external member. Therefore allowance is often spoken of as purely a designer's term.

Tolerance is the permissible variation allowed in the size of a part and is applied independently of the allowance. The application of tolerance should always be in the direction to produce a looser fit.

As before mentioned, both reports call for minimum hole basic; hence the tolerance is plus and makes the size of the hole, either plain or threaded, from basic to over basic by the amount of the tolerance.

For free fits the internal member (shaft member or screw) has its high limit basic minus the allowance; its low limit is basic minus the allowance and the tolerance combined.

To use the tables of either of these reports on standardized fits the engineer need only to choose the class of fit he desires for a pair of mating parts whether threaded or plain, and the table for that class of fit will have both the allowance and tolerance given, which will produce the kind of fit indicated.

For example, if the engineer knows that the threaded parts of a component may be subjected to rough treatment before assembly, become rusted, require plating or Sheridizing, and should be cheaply made, he should choose Class I, the Loose Fit, as this class provides a clearance or neutral zone between the smallest nut member and the largest screw to allow for these discrepancies, and still assemble easily. He should also choose the Class I, Loose Fit, of the Plain Gage Committee where accuracy is not essential and where some freedom in the moving parts is not objectionable.

Class II in either report should be chosen where much freedom of fit is objectionable and where a better fitting of the mating parts is desired. It should be borne in mind that each successive finer grade of fit in both reports is more difficult to produce and hence more costly.

There are a great many parts of Ordnance matériel which from their nature and use can well belong to the Loose Fit class, especially artillery carriages, straight thread adapters, boosters, etc.

Probably the largest amount of Ordnance work will fall in Class II, as this character of fit is accurate enough for everything except the most exacting, and the tolerances are large enough to produce on a large scale, economically. The threaded parts made according to Class II provide for no interference of metal and will assemble easily without force being applied.

Relation Between Production Engineer and Ordnance Engineer

This item of round hole tolerances has been referred to at length because of its fundamental importance and because it is typical of cases where practical production engineers can supplement the work of the Ordnance Engineer. There are innumerable other cases, such as detailed shape of castings and forgings, sizes and pitches of gears, specifications for physical properties of materials, etc., etc., where the designer may lose sight of the difference between peace time production and the enormous bulk production which must be obtained in time of war. The production engineer comes in contact with this difference in conditions as part of his daily work and every work and every effort should be directed toward obtaining his cooperation in the preparation of Ordnance design.

Precision Measuring Instruments Used in Gage Inspection

By

Dr. GEORGE K. BURGESS

THE field covered by the title "Precision Measuring Instruments" is extremely broad. This article, however, will be limited to a discussion of such apparatus as is applied in the measurement of dimensions of gages and tools used in the manufacture of machine parts, artillery ammunition, etc.

The precision required in some classes of modern interchangeable manufacture has caused much effort to be devoted to the improvement in design and construction of measuring apparatus. The resulting development has been so varied that a comprehensive description of all types of even this limited class of apparatus is scarcely possible in a single short article.

The purpose of a precision measuring instrument, of the kind dealt with in this article, is to determine accurately a dimension either by direct measurement or by comparison with a standard. The "working" length standards commonly used in this class of work consist of line standards, of which the steel scale is an example; contact or end standards, such as precision gage blocks; and micrometer screws. Under certain conditions light waves are also used.

Dr. George K. Burgess
Director, Bureau of Standards

All authentic measurements of length in this country, through the medium of appropriate standards, are derived from the fundamental standard of length of the United States, and through that from the International Standard.

The Measuring Machine

Intercomparisons of the various types of length standards may be accomplished by means of the apparatus known as a measuring machine, or comparator. A well known type is shown in Fig. 1. On such a machine a micrometer-microscope, attached to a head sliding along horizontal ways and bearing one measuring contact, serves to locate the contact attached to a stationary head, by bringing the cross-wires of the micrometer-microscope into coincidence with a graduation mark of the line standard which is attached to the machine. For intermediate positions between the divisions of the line standard, one of the contacts may be adjusted by means of a micrometer-screw.

The method of originating gage sizes by comparison with line standards, and of comparing end standards with line standards, was developed about forty years ago. Prof. Wm. A. Rogers, of Cambridge, Mass., probably did more than any other man toward the development of the types of measuring machines now made in this country. A comparator for this purpose has also been designed and built at the Bureau of Standards. The advantage in using a line standard is that the liability to wear is obviated. In view, however, of the more recent development of light wave interference methods, described later, for the intercomparison of contact standards, this objection to the use of contact standards is largely obviated.

Comparisons between a contact standard, such as a precision gage block, and a line standard may be made after inserting the contact standard between the measuring contacts of the machine. Factors which affect the accuracy of comparisons thus made are:

1. Straightness of the ways of the bed on which the sliding head moves;
2. Parallelism and straightness of the surface of the line standards, the ways, and the axis of the micrometer screw;
3. Absence of or compensation for lead errors, and absence of lost motion between the micrometer screw and nut;
4. Flatness and parallelism of the contact faces;
5. Pressure exerted against the contact faces; and
6. Uniformity of temperature conditions.

The first four of the above factors are governed largely by the precision of workmanship embodied in the machine. Straightness of the ways also depends on the design of the bed, which should be properly supported, and of sufficient depth to reduce distortion resulting from the usual stresses imposed to a negligible amount. Errors in measurement due to deviation of the axis of the standard and the line of measurement from parallelism are reduced to a minimum by the alignment of the line standard along the axis of the measuring contacts. This feature in design is not incorporated in all commercial measuring machines, as errors from this source are usually small when the machine is well constructed.

The fifth factor, namely, that of pressure on the contact faces, is provided for by embodying in one of the measuring heads an indicating device which shows when a definitely known pressure is attained. For controlling

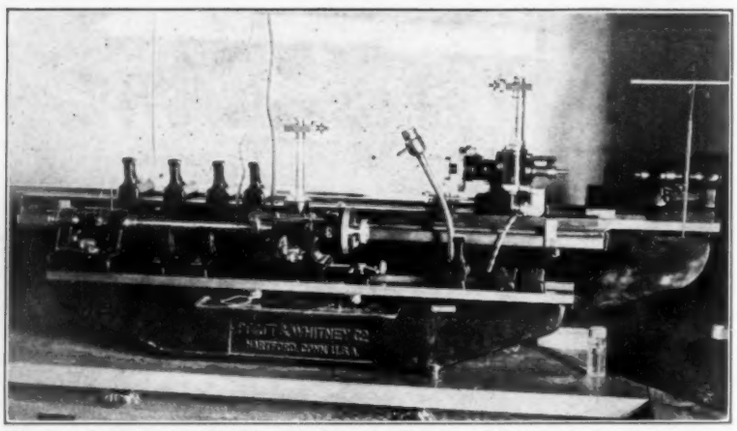


Fig. 1. A Measuring Machine Used at the Bureau of Standards for Determining Standards of Length

the sixth factor, a room maintained at constant temperature is desirable. In any case, precautions should be taken to allow the machine, line standard, and contact standard to come to as nearly a uniform temperature as possible. In case the line standard and the contact standard have different thermal coefficients of expansion, it is desirable that the comparison be made at standard temperature, which, in American practice, is 68° F, (20° C). If this cannot be done, a correction must be applied for the difference in the coefficients of thermal expansion. When the above precautions are properly observed, an accuracy of ±0.00001-inch per inch can be readily attained in making such comparisons.

The measuring machine may also be used to determine dimensions by comparison with contact standards. The difference in dimensions between the piece being measured and the standard is derived from readings of the micrometer head obtained by successive settings on each. The principle of measurement here applied is extended to a variety of instruments, as the bench micrometer, micrometer caliper, etc., which are commonly used for determining lengths and diameters when such can be readily determined by direct measurement.

There is an important distinction between direct and comparative measurement. The latter involves the use of a standard or model piece with which the piece to be measured is compared. Two observers making individual determinations of a given dimension on the same object with a measuring instrument, without each individually checking the measuring instrument against a physical standard in the same manner as the measurement is made, will seldom obtain exactly the same measurement, although both may be highly skilled. On the other hand, two observers using a model piece, or master gage as it is termed in commercial practice, to measure against, will usually obtain very nearly the same result. That is, dimensions of similar parts can be compared much more accurately than they can be originated. For this reason, master gages are essential in interchangeable manufacture on a large scale, and the entire procedure of mechanical inspection is based on a system of master inspection and working gages.

Precision Gage Blocks

Contact standards are much more extensively used than line standards in gage and tool inspection. In the form of sets of precision gage blocks, together with certain accessories, they are themselves very useful precision measuring instruments, on account of their accuracy, simplicity, and adaptability. A precision gage block is a block of metal, usually hardened steel, having two faces which are accurately flat and parallel, and a specified distance apart. Sets of gage blocks are available commercially, by means of which any dimension within a large range of sizes can be built up to the nearest 0.0001-inch by various combinations of sizes, as shown in Fig. 2. Accessories consist of extension pieces in the form of semi-cylindrical jaws, center-points, etc., which may be wrung onto gage-block combinations and the whole mounted to form useful measuring appliances such as an internal gage for measuring diameters of holes, a precision height gage, etc.

Test Indicators and Dial Micrometers

It is frequently impossible to make a direct measurement of a dimension, and in such cases means must be provided for transferring measurements from the work at hand to the contact standard, as, for example, in measuring the coordinates of a curved profile. In such cases a sensitive test indicator is essential. These us-

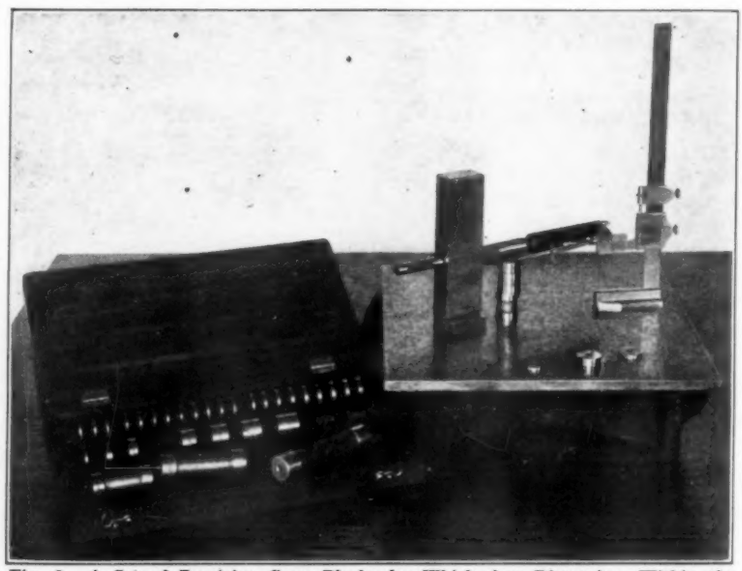


Fig. 2. A Set of Precision Gage Blocks by Which Any Dimension, Within the Limits of the Set, Can be Measured to Within 0.0001-inch

ually consist of a multiplying lever system, gear train, liquid column in a capillary tube, or other means for magnifying a slight displacement of a contact point. The indicator serves to detect, for example, any difference in dimensions between the height of a point on a part being measured and the height of a precision gage

block combination, nominally of the same height, with respect to a horizontal reference plane. When used for this purpose, a small range of motion of the contact point of the test indicator is sufficient, and, accordingly, the multiplying mechanism can be simple in design. In general it may be stated that, assuming good workmanship, the less complicated the mechanism, the greater is the degree of accuracy of the indication of the displacement of the contact point.

Some types of test indicators may be mounted on a base, on which a platform or anvil is arranged, to form precision comparators or amplifying gages. Some commercially available types of such comparators are shown in Fig. 3. These are especially useful for the inspection of parts produced in quantities on which very small tolerances are permitted.

Devices having a comparatively large range may be used as direct measuring devices, and as such may be classified as dial micrometers. These are very useful for certain classes of work, particularly in the inspection of manufactured products on which moderate tolerances are permitted, but their accuracy is usually somewhat less than that required in precision measurement, adapted for a special purpose. A typical dial micrometer is shown in Fig. 4.

Thus far there have been considered only those instruments which are more or less universal in their application. For the measurement of complex shapes, such as screw threads, gears, etc., various types of apparatus of special design have been developed.

Optical Projection Apparatus

Optical projection apparatus for measuring screw thread gages, taps, screws, etc., is one of the more important modern developments, and is now extensively used for measuring thread angle and examining thread form. It is also widely used for measuring small contours of tools and gages. Although the microscope has been adapted for such purposes, the projection apparatus has the advantage that measurements may be made with much greater rapidity and ease than with the microscope, and to at least the same degree of accuracy.

The optical system of such an apparatus consists of a source of parallel light, such as an electric arc or concentrated filament lamp with condensing lens system, a projection lens system, a screen, a device for holding the work in front of the projection lenses, and means for measuring the thread angle and other thread elements. The point source of light is at the principal focus of the condensing lens, and the resultant parallel beam of light is incident on the work being inspected. The projection lens or system of lenses receives light from the illuminated outline of the work and projects an image upon the screen.

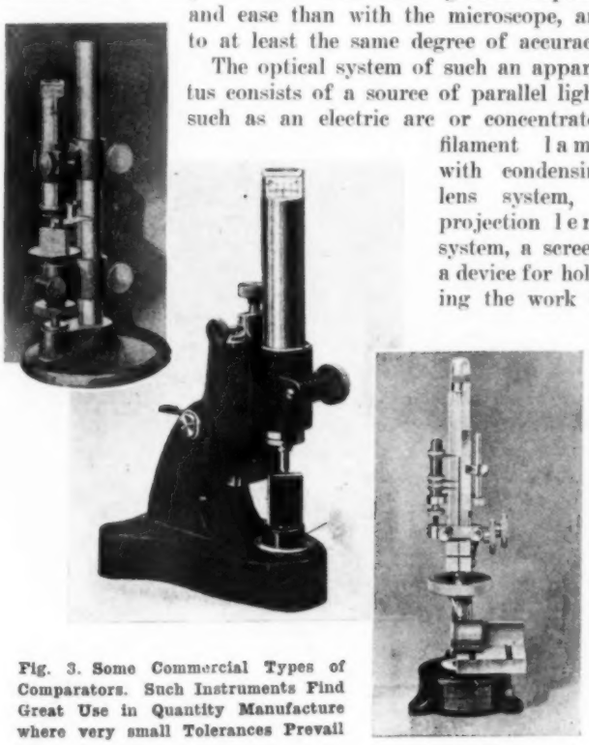


Fig. 3. Some Commercial Types of Comparators. Such Instruments Find Great Use in Quantity Manufacture where very small Tolerances Prevail

The image formed by an opaque object placed in such an optical system has the appearance of being a shadow,

Fig. 4. Dial Micrometer Used in Cases Where Moderate Tolerances Are Permitted

and is commonly designated a shadow-image, or simply a shadow. It is not a true shadow in an exact sense of the word, and the points on the object which lie outside of the conjugate focal plane of the projection lens, that is, points out of focus, do not give a sharp outline although they may actually intercept the incident light. Such points simply obscure or blur the images of points in line with them that are out of focus. For this reason, it is impossible to obtain a distinct image of a plane surface of any considerable width set parallel to the incident beam of light. Projection methods of inspection are, therefore, limited to the inspection of cylindrical, conical, and helical surfaces whose axes are perpendicular, or nearly perpendicular, to the optical axis of the projection lens, and to thin profile gages or templets, the elements of whose edges are straight lines parallel to the incident beam of light.

Various designs of optical projection apparatus have been developed, both in this country and abroad. One of the principal difficulties encountered in such development was that of securing accurately corrected projection lenses which project a field free from measurable distortion. It is also desirable that the lens have a short focus, in order that a reasonably large magnification may be secured at a short screen distance, so that the details of the projected shadow-image may be easily seen by the operator at the lantern. In the apparatus now in use at the Bureau of Standards, shown in Fig. 5, the projection lens system consists of a wide-aperture microscope objective and a Ramsden eyepiece. By means of a Ramsden eyepiece having a magnification of five, and microscope objectives having 48, 32, and 16-mm. focal lengths, magnifications of approximately 50, 100, and 250, respectively, are obtained at a screen distance of about five feet.

The means for measuring thread angle in the present improved Bureau of Standards design, known as a "shadow-protractor," is an integral part of the projection lens system. A 60° angle, in the form of a thin metal plate having beveled edges, is mounted perpendicular to the optical axis at the focal plane of the eyepiece, and both are mounted in a revolvable drum graduated in degrees about its circumference. A slow-motion adjustment of the position of the standard angle consists of a handwheel, graduated to read to minutes of arc of the drum, mounted on a worm shaft which engages with a worm gear cut in the periphery of the drum. In making angle measurements, one side of the standard angle is brought nearly into coincidence with one side of the angle to be measured, such that a very fine line of light of uniform width is visible. The graduated head is then read. If the other side of the standard angle and the angle to be measured are also parallel the two angles are equal. If not parallel, the standard angle is rotated until parallelism is obtained. The graduated head is then again read and the difference between the two readings of the graduated head is the amount by which the angle under test differs from the standard angle.

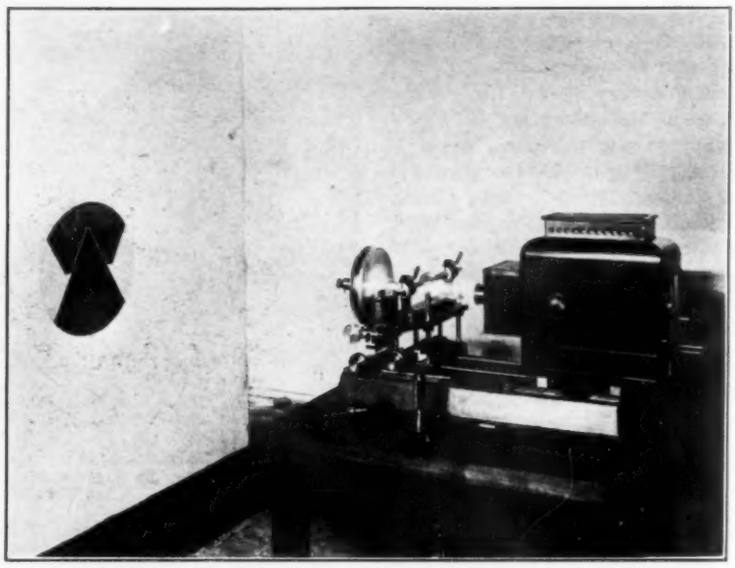


Fig. 5. Optical Projection Apparatus Used for Measuring Screw Thread Gages, Taps, Screws and Small Contours of Tools and Gages

Optical projection apparatus may also be used to inspect the angle and thread form of an internal thread by projecting a cast of a segment of the thread, made by pouring into the thread a fused mixture of sulphur and powdered graphite.

This apparatus is also well adapted to the measurement of pitch to a fair degree of accuracy when the higher magnifications are used. The movement of a slide, mounted on hardened steel balls in V-grooves, in an axial direction of the screw is measured by means of precision gage blocks inserted between the spindle of a micrometer attached to the base plate and a spherical contact point on the slide, using the shadow image of the standard angle as an index. In measurements of pitch a setting is first made with the image of one edge of the standard angle in coincidence with one side of the thread image, and with a thin precision gage block inserted between the micrometer and ball contact. The work is then displaced laterally and another gage block, equal in thickness to a nominally integral number of threads, is wrung to the first gage block and inserted. If the lead is correct, the edge of the standard angle will again coincide with the side of the thread. If not in exact coincidence, the amount by which the micrometer screw must be turned to bring it into coincidence is the lead error in the thread interval measured.

Lead Measuring Machines

In order to obtain intimate knowledge of variations in lead of a screw thread, it is necessary to measure accurately the pitch from thread to thread. A variety of devices for this purpose have been developed, but these differ very little in their basic principles.

In such machines, a measuring contact-point touches the sides of the thread, and is usually attached to some kind of indicating device, such as a multiplying lever system, which serves to indicate when a given condition of contact is reproduced, when the point is inserted in successive threads. The axis of the gage is held on, or parallel to, a given line, and means are provided for measuring relative motion of the gage and measuring contact parallel to the axis of the gage. This measurement is usually accomplished by means of a micrometer screw, which is especially accurate as to periodic and local lead errors and whose progressive lead error, if any, is accurately known, but contact or line standards are also used for this purpose. Thus, the essential conditions necessary in such a device are:

That the axis of the gage and the line of measurement be accurately parallel.

That contact conditions of the indicating point in successive threads be accurately reproduced.

That length standards be so incorporated or applied in the machine that an accurate measurement of the relative motion of the contact point and gage, parallel to the axis of the gage, be readily accomplished.

The lead testing device shown in Fig. 6, based on a design originated at the National Physical Laboratory of England and developed further at the Bureau of Standards, embodies these fundamental principles and has been found most satisfactory for measuring lead errors of both plug and ring thread gages. By means of this machine, direct measurements of pitch between any two threads may be made; a special micrometer screw, having a straight line calibration curve to within 0.00002-inch, and provided with a head graduated directly to indicate 0.0001-inch, being the means of measurement. The method of operation of this machine is as follows:

A ball pointed stylus a, Fig. 6, rests in the groove of the thread to be measured and is supported at the end of a floating arm b, which carries a lens c, at the other end. The arm b is supported by a flexible flat steel spring d, and the movable support upon which the spring is carried is so adjusted that the spring d exerts a slight pressure on the floating arm b, which tends to cause the stylus a to bear firmly against the sides of the thread. When the stylus is resting evenly on both sides of the thread, the lens c is directly beneath the lamp e,

and the image of the straight filament in the lamp e is projected by the lens c downward to a glass prism, by which it is reflected under the machine to a second prism, and is again reflected by this prism to the screen s. When the image of the filament coincides with a reference line on the screen s, the micrometer m is read and the reading recorded. The turning of the micrometer head m causes the carriage supporting the micrometer, stylus, lens, lamp, prisms and screen to move with reference to the thread, which remains stationary. Upon moving the micrometer head an amount corresponding to one thread interval, the stylus comes to a position in the next thread similar to the position in the preceding thread, and the micrometer setting is adjusted until the image of the filament coincides with the index line as before. The micrometer reading is again recorded and the difference between the two micrometer readings is the thread interval traversed.

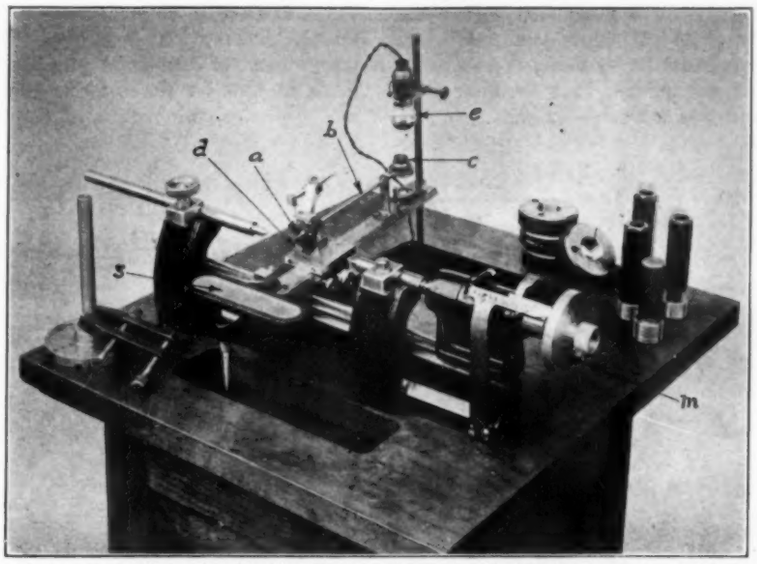


Fig. 6. Lead Measuring Machine Used in Measuring the Pitch of a Screw Thread

In a similar manner each thread interval along the gage may be measured, and the maximum variation in lead over the entire threaded portion of the gage may be determined along a line parallel to the axis of the screw. Another such test along a line at 180° around the screw from the first is usually sufficient to completely inspect a thread gage for lead errors. The stylus, lens, lamp, reflectors, and screen merely form a sensitive optical indicator for the micrometer settings. For the measurement of thread ring gages, a swivel arm attachment is used to introduce the stylus into the internal thread, as shown at t in Fig. 7.

Apparatus for Measuring Pitch Diameter

The only feature of an apparatus for the precision measurement of the pitch diameter of an external thread which differs essentially from ordinary measuring devices is the form of the contact. Knife-edge wedge-shaped contacts which make line contact with the sides of the thread have been successfully used; however, the usual method of making such measurements is to insert small accurately ground cylinders, or "wires," into the thread groove, two on one side and one on the other, of such size that they touch the sides of the thread near the pitch line. The pitch diameter is then derived from measurements made over the wires by means of a measuring machine, micrometer caliper, or other means. Fixtures for supporting the work and wires, or the micrometer caliper, have been devised for convenience in manipulation. The so-called "three-wire method" of measuring pitch diameter may be satisfactorily applied to all except very fine pitch screws, and threads of very small thread angle.

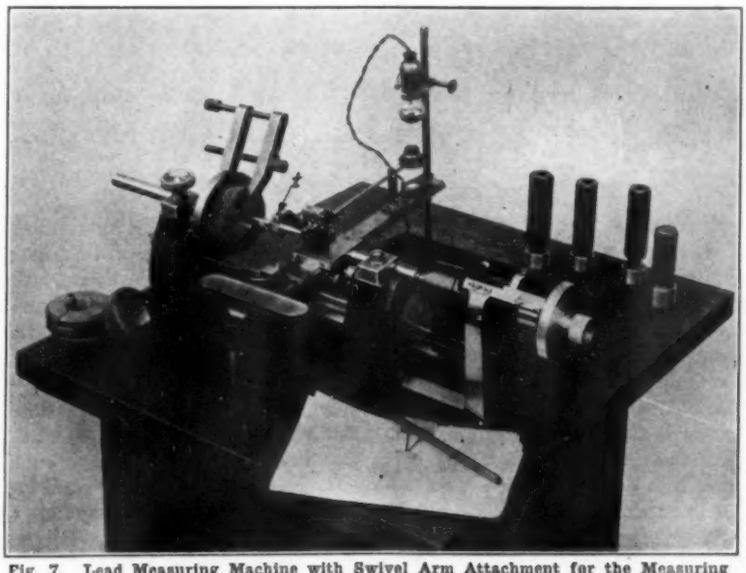


Fig. 7. Lead Measuring Machine with Swivel Arm Attachment for the Measuring of Thread Ring Gages

With regard to determining the pitch diameter of an internal thread, that is, of a thread ring gage, the application of direct methods of measurement presents serious difficulties, particularly in securing proper contact pressure, when a high degree of precision is required. The usual practice is to fit the ring gage, which is adjustable through a small range, to a master setting plug, measure the plug, and assume that the ring is of the same diameter as the plug, which it fits. When the thread ring gage is of correct lead, angle, and thread form, within very close limits, this method is quite satisfactory and represents standard American practice. It is the only method available for very small sizes of threads. For the larger sizes, more or less satisfactory methods of direct measurement have been devised, and two types of machines have been developed abroad for which high accuracy is claimed. (*Engineering*, Vol. 112, Oct. 21, 1921, p. 558; Vol. 114, Aug. 18, 1922, p. 213.)

Measurement by Light Waves

The use of light waves as length standards was mentioned at the beginning of this article. These waves have all the necessary properties of length standards. A wave of any given color, such as those emitted by incandescent pure cadmium, helium, or neon, is constant in length, accurately reproducible, and may be readily applied in measurement by methods which make use of interference

of light waves. The length of a precision gage block, selected for its accuracy as to planeness and parallelism of its surfaces, may be determined by using it as a separator for two interferometer plates, thus forming what is known as a Fabry and Perot interferometer.

Thus, after applying various small corrections depending on the density and humidity of the air, lack of exact parallelism of the gage surfaces, the thickness of the metallic film on the interferometer plates, temperature, and pressure, the length of the gage block at standard

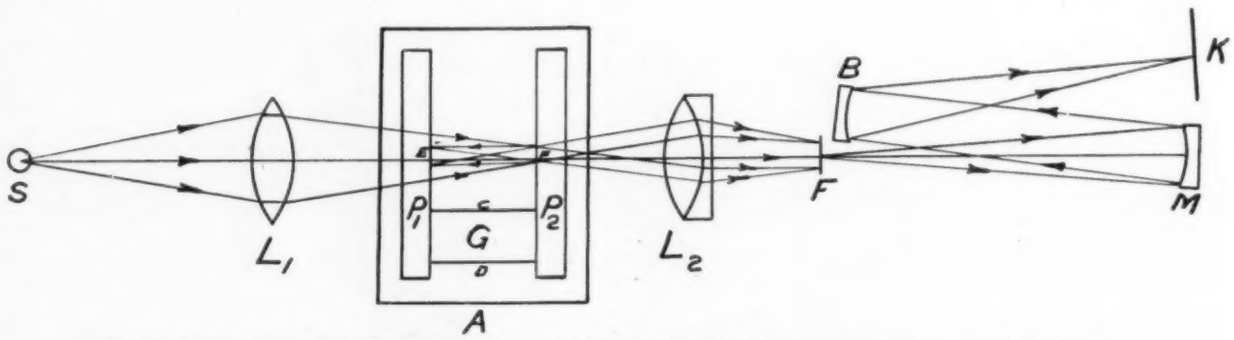


Fig. 8. Diagram of the Optical System Used in Determining the Length of a Gage by Means of Light Waves

The optical system for determining the length of a gage by means of light waves is shown in Fig. 8. "The interferometer formed by the gage and plates is placed within a constant temperature chamber A in front of the slit of a grating or prism spectograph. Light from the neon lamp S is focused by the lens L_1 upon the interferometer P_1 P_2. Part of the light is transmitted directly through the interferometer, part is reflected by the platinized surface of P_2 to the platinized surface of P_1, where it is again partially reflected, and then a part of it passes on through P_2, and so on through a large number of multiple reflections and transmissions. The reflected and directly transmitted parts when combined produce a system of interference rings which is focused by the lens L_2 upon the slit F of the spectograph. The images of the slit corresponding to the different radiations from neon are separated by the grating B and recorded on the photographic plate K."*

By measuring the diameters of the interference rings thus photographed, knowing the nominal length of the gage, it is possible to calculate the exact number of light waves, and fraction of a wave, between the plates. temperature is obtained to within 0.000001-inch.

Having accurately determined in this manner the lengths of a set of standards, comparisons of gages of nominally the same lengths may be accomplished with speed and precision. The gage to be measured and the standard are placed side by side in intimate contact with the true plane surface of a glass plate and the distance between the planes of the two upper surfaces is then determined. This is done by examining interference bands produced when another glass true plane is superimposed in such a way as to form two thin wedge-shaped spaces between the gage surfaces and the glass plate, the apexes of the wedges being in the same straight line. Comparisons between gage blocks and other objects, such as spheres and cylinders, may be accomplished in a similar manner.

The foregoing is at best only a brief description of the types of apparatus used in precision measurement of tools and gages. Each of the types mentioned might well be made the subject of a lengthy article.

* Quoted from "Interference Methods for Standardizing and Testing Precision Gage Blocks" by C. G. Peters and H. S. Boyd, Bureau of Standards Scientific Paper No. 436.

Pan American Standardization Conference

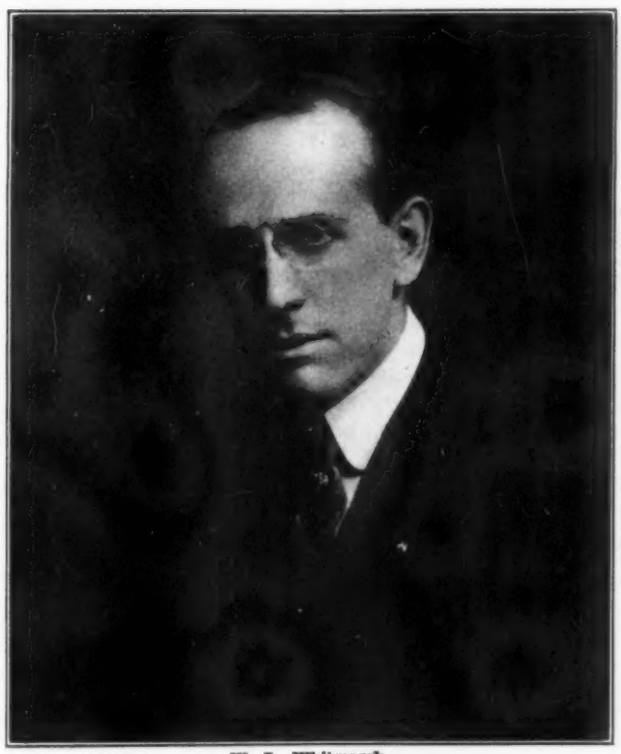
At a meeting of the Governing Board of the Pan American Union held at Washington, D. C., Wednesday, April 2nd, the following were appointed to membership on the Pan-American Railway Committee, the reorganization of which was entrusted to the Governing Board by a resolution adopted at the Fifth Pan-American Conference held at Santiago, Chile, in 1923: Mr. Juan A. Briano, of Argentina; Mr. Tobias Moscoso, of Brazil; Mr. Santiago Marin Vicuna, of Chile; Mr. Francisco P. de Hoyos, of Mexico; Mr. Charles M. Pepper and Mr. Verne L. Havens, of the United States. One vacancy remains to be filled, and it is expected that action on this vacancy will be taken at an early meeting of the Board.

The Board, among other transactions, decided to refer to a special committee the question of the date and place of meeting of the Pan-American Standarization Conference, also provided for in a resolution adopted at the Pan-American Conference held last year at Santiago, Chile. The purpose of this Conference will be to consider the question of uniformity of nomenclature and the standardization of specifications of raw materials, supplies, tools, machinery, equipment, and other merchandise, with a view to reaching agreements which may be embodied in Inter-American conventions.

Modern Precision Measuring Instruments

By

W. L. WHITMARSH



W. L. Whitmarsh

TWO classes of precision measuring instruments are found in the modern machine shop—the working tools, or those used for measuring the product, and those kept for the purpose of setting and checking the accuracy of the working tools.

In the first group are micrometer calipers, vernier tools, and limit gages of several types; also amplifying gages of the dial type, and those registering measurements by means of a column of fluid in a glass tube. The second group embraces checking and master gages, standard reference disks and rods, and sets of precision gage blocks that can be used singly or built up in multiples to desired lengths. In shops manufacturing gages are to be found finely calibrated measuring machines, and such equipment as optical flats and the interferometer for taking measurements by the light wave principle.

The necessity for all of these different kinds of precision instruments is explained and the history of their development recorded elsewhere in this issue. It is the purpose of this article to describe the standard types, their functioning, and use. Instruments graduated in English measure are described, although it should be understood that most standard types are also made with metric system graduations.

The Micrometer Caliper

The most familiar form of micrometer caliper is illustrated in Fig. 1. Mechanics, machine operators, bench hands, and inspectors possess this tool wherever fine measurements are required in mechanical work. Larger sizes, together with variations and adaptations of the tool are to be found in the tool equipment of the modern machine shop.

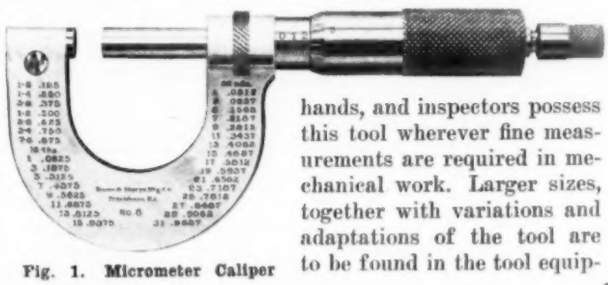


Fig. 1. Micrometer Caliper

The reason for the popularity of this tool is that it is the most complete, reliable and handy measuring instrument that can be purchased at a nominal price, and with it an extremely wide range of fine measurements may be taken.

The principle of the micrometer is that of a fine pitch screw, accurately cut on a spindle and threaded into a fixed nut. By screwing the spindle in or out of the nut, the measuring points are brought into contact with, or withdrawn from, the piece to be measured. With the measuring points in light contact with the piece, the measurement is read in thousandths of an inch from graduations engraved on the tool.

Fig. 2 shows the screw A cut on the portion of the spindle that is concealed within sleeve B, and the fixed nut is at C in hub D. The pitch of the screw is forty to the inch. The graduation of the hub, D, in a line parallel to the axis of the screw, is forty to the inch, and is figured 0, 1, 2, etc., every fourth division, representing 0, .100″, .200″, etc. As the graduation conforms to the pitch of the screw, each division equals the longitudinal distance traversed by the screw in one complete rotation and shows that the caliper has been opened one-fortieth or .025 of an inch.

The beveled edge of the sleeve, B, is graduated into twenty-five parts and figured every fifth division, 0, 5, 10, 15, 20. Each division, when passing the line of graduations on the hub, indicates that the screw has made one twenty-fifth of a turn and the opening of the caliper increased one twenty-fifth of one-fortieth, or one one-thousandth of an inch.

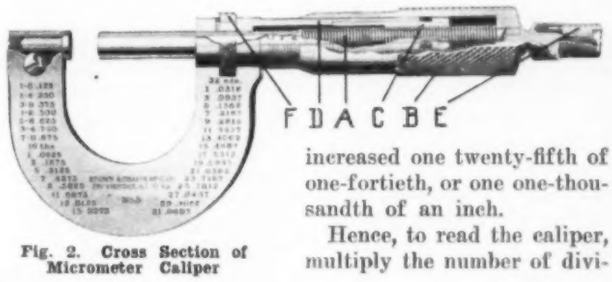


Fig. 2. Cross Section of Micrometer Caliper

Hence, to read the caliper, multiply the number of divi-

sions visible on the scale of the hub by twenty-five and add the number of divisions on the scale of the sleeve from zero to the line coincident with the line of graduations on hub.

Most micrometer calipers read to one-thousandth of an inch, but one-half and one-quarter thousandths are readily estimated. They are also made with a vernier on the hub, Figure 3, by means of which measurements may be read in ten-thousandths of an inch.

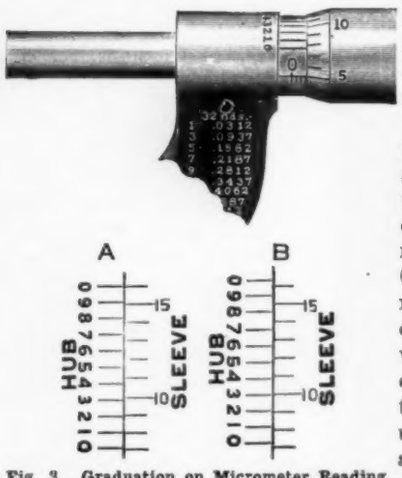


Fig. 3. Graduation on Micrometer Reading to Ten-Thousandths of an Inch

In reading such a tool, the thousandths are noted as usual, then the number of divisions on the vernier, commencing at 0, until a line is reached that coincides, or matches, with one of the lines on the sleeve. If the second line, figured 1 at A, matches a line on the sleeve one ten-thousandth is added; if the fourth line, figured 3 at B, matches, 3 ten-thousandths are added.

The small knurled projection E, Fig. 2, is known as a ratchet stop and is for the purpose of gaging the contact with pieces measured so that the measuring points are brought to bear with an equal pressure each time the tool is used. If this pressure is increased the ratchet will slip. This device is also used for rapid setting of the measuring points by rolling the small diameter between the thumb and forefinger.

Not all micrometers are equipped with ratchet stops for many workmen prefer to depend on their highly developed touch, or sense of feeling, in bringing the measuring points in contact with the work each time with the same degree of pressure.

A clamp ring F, Fig. 2, is another device found on many micrometer calipers and is for the purpose of clamping the spindle to preserve a setting when it is desired to use the tool as a fixed gage for testing the size of consecutive pieces.

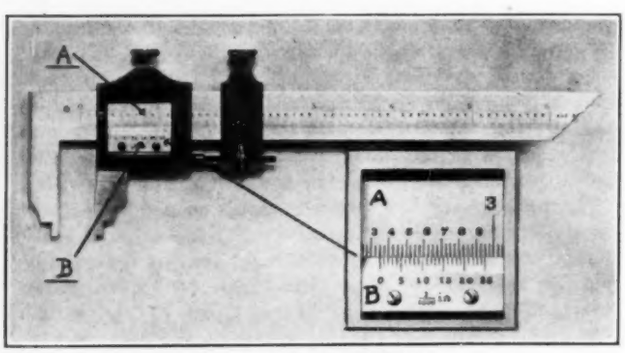


Fig. 4. A Vernier Caliper

The micrometer principle, as embodied in various standard tools and in many special measuring and testing devices is, without question, more generally used than any other in taking measurements in the average machine shop today. An endless variety of fixed gages, or those with limited adjustment, would be required for the range of measurements that may be taken with a single micrometer. When, however, the volume of production of like pieces increases to a point where the original cost and maintenance of a series of fixed gages is warranted, the micrometer often gives way to such gages.

Vernier Tools

The vernier on measuring tools is an ingenious application of a small auxiliary scale which, on account of its definite differential with the true scale on the bar of the tool, enables measurements in thousandths of an inch to be read from comparatively widely spaced graduations on both scales.

A vernier caliper is shown in Fig. 4. The vernier caliper, height gage, and depth gage are not found so often on the manufacturing floor of the shop as in the toolmaking department, where they are almost indispensable, particularly the height gage.

There are cases, however, in the shop where a large vernier is preferable to a large micrometer. It is much lighter, and this often enables the "feel" or pressure of the measuring points on the work to be more sensitively gaged. There are other cases where the sleeve, or some other part of a micrometer frame, will interfere with the work in such way that it is troublesome, or impossible, to take a measurement. A vernier caliper will often solve such a difficulty.

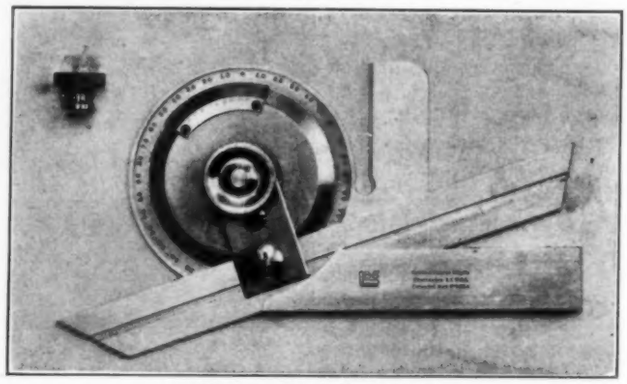


Fig. 5. Bevel Protractor

Another advantage is that both external and internal diameters, within access, can be measured with a vernier caliper, for the scale is usually graduated on one side for outside and on the other for inside measurements.

On the other hand, it is not possible to use the vernier caliper as generally as the micrometer caliper, because the short length of the jaws prevents measuring large diameters except on, or near, the end of the piece.

The principle of the vernier will be understood from the following explanation of the graduation and reading of the scales.

The true scale A on the bar of the instrument in Fig. 4 is graduated into inches, which, in turn, are divided into tenths of an inch, numbered 0, 1, 2, etc. Each tenth is subdivided into four parts, making the finest divisions equal to 1/40 of an inch, or .025". The vernier B on the sliding jaw of the tool is divided into twenty-five parts, numbered 0, 5, 10, 15, 20, 25. These twenty-five parts correspond, in extreme length, with twenty-four

parts, or twenty-four fortieths of an inch, on the true scale A.

$$\frac{24 \text{ divisions on true scale} \times .025''}{25 \text{ divisions on vernier}} = .024'' \text{ per division on vernier.}$$

If the divisions on the true scale are 1/40 of an inch, or .025, apart and those on the vernier .024″ apart, there is a difference in length between a division on the true scale and one on the vernier of .025″ — .024″ = .001″.

When the reading is exact, with respect to the number of fortieths of an inch, the 0 on the vernier coincides with a graduation on the scale A—either inch, tenth or fortieth, as the case may be. This leaves a space between lines on the scale and the 1, 2, 3, 4, 5, 6, etc. lines on the vernier of .001″, .002″, .003″, .004″, .005″, .006″, etc., respectively, the difference increasing .001″ at each vernier division in numerical order until, at the 25th graduation, the lines again coincide.

Thus, when the 1st, 2nd or 3rd, etc., line on the vernier coincides with a line on the scale, the 0 on the vernier has moved 1, 2, or 3, etc., thousandths of an inch past the previous fortieth graduation on the scale.

To read—Note the inches, tenths and fortieths of an inch that the 0 on the vernier has moved from the 0 on the scale and to this reading add the number of thousandths indicated by the line on the vernier that coincides with a line on the scale. As an example, in Fig. 4, the enlarged section shows the 0 on the vernier coinciding with a fortieth line on the scale. The reading is 2 inches plus 3 tenths plus 2 fortieths,, or 2.000″ + .300″ + .050″ = 2.350″.

Vernier Bevel Protractor

An illustration of the vernier principle in circular measurement is shown in Fig. 5.

Bevel protractors are used in all classes of work where angles are to be laid out, and the application of the vernier to this tool makes possible the reading of measurements to 1/12 degree, or 5 minutes.

The dial of the tool is graduated to degrees. On the vernier, 12 divisions occupy the same space as 23 divisions on the dial. This makes a difference of 1/12 degree or 5 minutes between the width of one space on the vernier and two spaces on the dial.

The vernier on this tool is read in a manner similar to that on tools previously described. The whole number of degrees between 0 on the dial and 0 on the vernier are taken; then the lines on the vernier are counted in the same direction from 0 to the division that coincides with a line on the dial, and for each line on the vernier so counted 5 minutes are added to the measurement.

An instrument known as an Amplifying Dial Gauge is used in production departments to measure successive pieces as they are removed from a machine, and in inspection departments to check the measurements of quantities of duplicate pieces. It is fast to use and does not depend on the "feel," or sense of touch of the operator, but pieces measured must be removed from the machine as the gage cannot be conveniently used like a micrometer caliper to take a measurement while the work is in position in a machine.

The dial of this instrument is graduated in tenths of thousandths of an inch and the indicating hand is actuated by a vertical plunger coming in contact with the piece to be measured. The plunger is raised as the work is passed between it and the anvil, and connecting levers amplify this movement and transmit it to the dial mechanism which causes the indicating hand to register the measurement.

The arm carrying the indicating mechanism is adjustable vertically to accommodate pieces of different heights. Standard blocks or fixed gages are used for setting the amplifying gage.

Fluid Gage

The fluid gage shown in Fig. 6 is used in a manner similar to the amplifying dial gage. This instrument, as its name implies, has a glass tube containing a column

Fig. 6. Fluid Gage

of fluid, with an adjustable scale graduated to tenths of a thousandth of an inch. The measuring point is a plunger that acts upon a diaphragm which, in turn, forces the fluid up the glass tube. The bore of the tube is small and consequently minute upward movements of the measuring plunger are greatly magnified when observed in the rise and fall of the column of fluid in the tube.

Limit Gages

In describing the use of the micrometer caliper, it was mentioned that when the volume of production of duplicate pieces is sufficient to warrant the cost and upkeep of fixed gages such gages are often used. Fig. 7 shows a variety of fixed gages used in manufacturing. Gages of this type eliminate the necessity of having to read a measurement, the workman having definite fixed sizes to work to. On the other hand, the measuring surfaces of such gages wear and, unless regular and frequent checking is made a rule and all worn gages promptly repaired or replaced, there is no assurance that accuracy of measurements will be maintained even with the most elaborate sets of such equipment.

Limit gages, as made for internal measurements, have two diameters. A hole in a piece of work is said to be "within limits" if the "GO" or smaller diameter gage can be inserted and the "NOT GO" or larger diameter gage cannot be entered; likewise the external diameter of a piece is "within limits" if the larger opening in the gage will pass over the diameter and the smaller opening will not.

In making internal limit gages, or plug gages, it is the practice to make the gaging surface of the "GO" gage longer than that of the "NOT GO" gage. This is because more wear is borne by the "GO" gage which is inserted in the hole, but it also serves another purpose

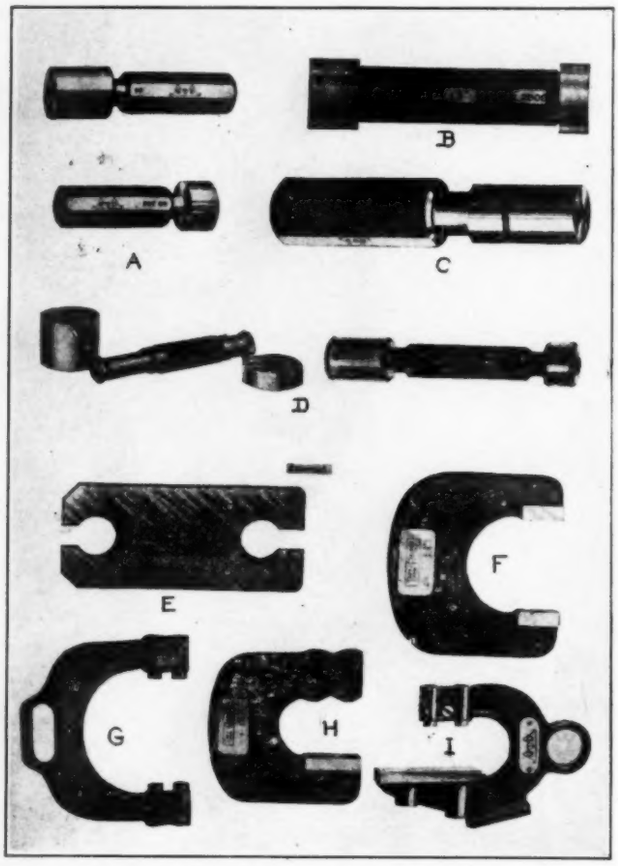


Fig. 7. Types of Fixed Limit Gages Used in Commercial and Munitions Manufacture

of identifying this gage, so that the workman does not have to look at the marking each time he uses a gage.

Internal limit gages are often made as two separate plugs, as shown at A, Fig. 7. The advantage of this is that when the "GO" gage wears it is discarded and a new one is made to pair with the "NOT GO" gage. A solid plug with the gaging surfaces at opposite ends is shown at B, and at C is one with both gaging surfaces on the same end. The type shown at C is perhaps a little quicker to use, particularly in inspection work, for it does not have to be withdrawn and turned end for end. At D are shown gages in the form of separate cylinders that can be attached to a handle, but, to be effective, the method of fastening the cylinders on the handle must be very secure, otherwise the least shake or looseness between the handle and gage may be mistaken for oversize in the hole being gaged.

Several types of external limit gages are shown in Fig. 7. The gage at E is made of flat stock; it is useful when gaging close to a shoulder, or in places where the diameter or length to be measured is accessible to a thin gage only. At F a solid snap gage is shown, the outer opening of which is the "GO" part of the gage, and the inner opening the "NOT GO." Adjustable snap gages are shown at G and H, the one at G having all four measuring points adjustable, while that at H has two adjustable points and a solid anvil. At I a similar type of gage is shown with an adjustable anvil made for inspection work. The makers usually provide means by which the measuring points of the adjustable gage described can be sealed when once set, in order to guard against the workman changing the setting.

Standard Internal and External Gages

Fixed gages are made in standard sizes which are kept for reference purposes in checking the accuracy of the tools used for measuring the product. Such gages are also made to special sizes for each piece of work and kept as master gages. Sometimes the gages for actually measuring the work are made in one of these forms but more often such tools are made as limit gages which are described above.

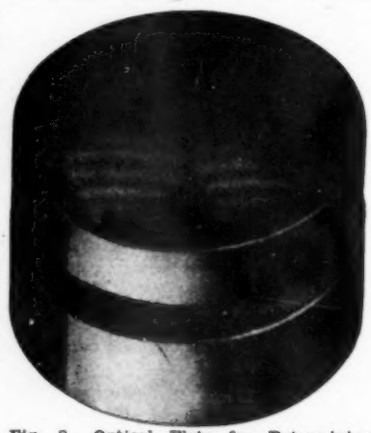


Fig. 8. Optical Flats for Determining Flatness, Length and Diameter by Light Wave Interference

In furnishing measuring instruments to be used for reference or for actually measuring the product in machine shops it necessarily follows that the gage manufacturer must work to much finer limits than the machine shop in order to insure the accuracy of gages and instruments produced. To do this, we must have finely calibrated measuring machines and other precision measuring equipment.

Optical Flats

A method of determining flatness, length and diameter measurements by light wave interference is illustrated in Fig. 8.

Optical flats are thick glass disks, each having one surface finished accurately flat. The glass has no magnifying power and is simply a very accurate transparent flat test surface.

Work tested under these flats is usually viewed in a monochromatic light (light of one wave length or color), which is produced by placing a tungsten filament light behind a panel of selenium diffusing glass. This glass cuts out the wave lengths of the violet, blue, green, yellow and orange light; and transmits only a definite red wave length. Light reflected from the upper surface of work being tested interferes with light reflected from the contacting surface of the upper glass flat, resulting in the formation of dark interference bands that are plainly visible to the naked eye and have an equivalent measuring unit of 12.5 millionths of an inch per band, or 8 dark bands to the ten thousandth of an inch.

(Continued on page 400)

How the Ordnance Department Has Solved Its Gage Problem

By

J. O. JOHNSON

ASSUMING that the preceding articles pertaining to interchangeable manufacture and the importance of gages in quantity production, have been read, I will endeavor to give a brief outline of the accomplishments of the Gage Section of the Ordnance office toward eliminating the difficulties encountered during the World War, and, as far as possible, the gage policy to be followed in the future.

All gages which became the property of the Ordnance Department after settlement of war contracts have been gathered into the several manufacturing arsenals where the material to which these gages pertain is manufactured. The first problem was to check dimensions of these gages for accuracy to be sure that none but serviceable instruments went into storage. This accomplished, the gages were slushed with grease to prevent oxidation, and, as added precaution, they are wrapped in moisture-proof paper and stored in proper rack, bin and tray.

The accompanying illustrations show the gage laboratory and gage storage at Frankford Arsenal. Other manufacturing arsenals have similar facilities with minor changes in layout due to local conditions.

Major J. O. Johnson

Finding itself with about a half million gages to take care of, the responsible officials of the Ordnance Department saw the need for an adequate record system. Such a system has been installed. Four cards are made for each gage, giving the following information: location of gage, gage drawing number, component drawing number, type of gage, function of gage or where to be used; identification number, latest revision of gage and component drawing, and approximate value of gage. Two of these record cards are sent to Washington for the master file of all gages, and two remain in the gage laboratory at the arsenal where the gage is located.

The war time organization of the Gage Section, as illustrated in the accompanying chart, is explained as follows:

Main office in Washington, divided into three sections.

Sec. 1, Design of gages: This section is responsible for all drawings and designs pertaining to gages, all drawings before distribution to be signed by the chief of the gage section. The design section must also keep in close touch with the various divisions in order to keep up with the changes in designs and see that gage drawings are up to the last revision of component.

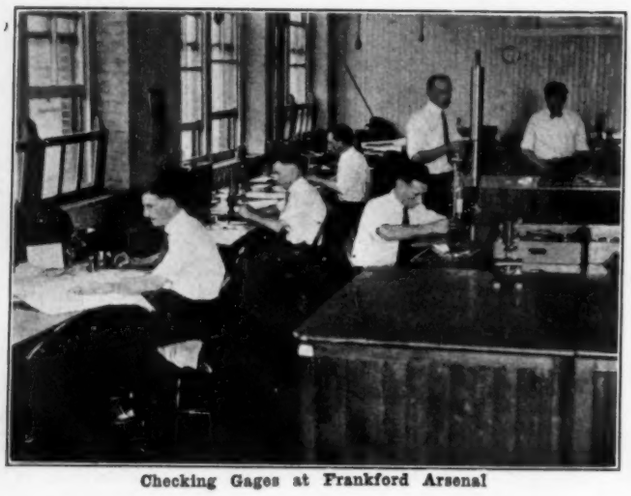
Sec. 2, Procurement: This section receives requests from district offices as to requirements and directions for distribution of gages, places orders for master checks and inspection gages with the gage manufacturers, designates one of the gage laboratories to inspect these gages, either locally or at the gage manufacturer's plant, keeping in close touch with the gage laboratories, and also sees that these inspections are carried out in the most efficient and economical manner consistent with the saving of time. It also sees that gages, after their acceptance by the gage laboratory, are distributed to their respective places. This office is responsible for all gages from the time orders are placed until gages have reached either the district office or the contractor by whom they are to be used.

Sec. 3, Administration: This section receives and distributes all information, technical and otherwise, and performs all other duties incident to the administration of this section, such as accountability, personnel, etc.

A gage laboratory has been organized at each arsenal for gages pertaining to the matériel manufactured at that arsenal. These laboratories have been working for the last four years and results are very satisfactory. They are laid out with all necessary tools and equipment for quick expansion, which will be necessary in time of war. When orders for the manufacture of gages are placed by the Washington office one of these laboratories will be designated to arrange for the inspection of these gages, either locally or at the gage manufacturer's plant. The gage laboratories are responsible for the acceptance or rejection of the gages. When gages have been inspected the results are sent to the Washington office where the accountability is carried. The laboratories will then distribute the gages either to the district offices or direct to the contractor's plants upon request and under direction of the district office through the procurement section.

As soon as an emergency arises a gage supervisor will be immediately installed in each district office with a suffi-

cient number of gage checkers to take care of Government gages for ordnance matériel manufactured in the respective districts. This method was used in the world war and worked very satisfactorily. This part of the district office organization will be under direct supervision of the Washington office.



Checking Gages at Frankford Arsenal

Wrapping Gages in Moisture-proof Paper for Storage

The reason for the centralized authority of this product is that it is of the most difficult technical nature and requires highly specialized, technically trained personnel. There are not at present available in the country—and by the nature of the business probably never will be—enough qualified men to enable the Ordnance Department to set up more than one good organization of this nature. Another reason is that gages are the Government inspector's standards upon which ordnance matériel is accepted or rejected, and upon such acceptance or rejection the Government pays the contractor. It may be readily seen that there can be no division of authority, as this would lead to endless disputes and confusion.

The procurement of Government gages can eminate from the Washington office, and can be distributed to the gage manufacturers to a better advantage, both as to saving of time and money, as they would be segregated, and as far as practicable, secured in quantities. Each gage plant requires a number of master checks and special tools to manufacture gages, and with the proper segregation from one source less quantity of these checks and tools would be required —a saving both of time and expense.

Immediately upon an emergency, the gage laboratories located at each manufacturing arsenal will become schools of instruction for gage checkers, and the district offices will be furnished with trained personnel from these laboratories. In this way all will check the gages by the same method, which will eliminate confusion in gage checking.

The Ordnance Department has at present about 500,000 gages for all classes of ordnance matériel, worth approximately $35,000,000. Organized as laid down in the accompanying chart will mean centralized procurement and decentralized distribution through the gage laboratories.

The Ordnance Department should furnish the civilian contractor with inspection gages used by its inspectors for the acceptance of finished material, for following reasons:

First. It has to check these gages and be responsible for their accuracy. In so doing it has to furnish checks which, in many instances, are most expensive and have to be made before the gage itself can be made.

Second. It can place orders to better advantage by using larger quantities; it can segregate and place them where it can get better delivery and better quality and price, as price on gages is largely governed by the quantity of gages made of the same kind and at the same time. Usually there are several special tools to be made before the manufacture of the gage, which cost as much as the gage itself, and it may be readily seen by this alone there would be considerable saving effected both in time and money by avoiding duplication in the manufacture of these tools. Master checks have to be made for checking gages; these same checks could then be used by the gage manufacturer, which would insure better and more uniform gages, as well as saving in time.

Gage Storage Racks and Bins at Frankford Arsenal

Third. This procedure will avoid disputes and friction with contractors, and will eliminate excuses and delays.

Fourth. It will be in a position to know when a contract is let and will immediately take steps to secure the gages necessary for the contract.

Fifth. Its source of information would be far more authentic as to who could make certain kinds of gages to the best advantage and give best delivery, and with Government pressure would be better able to control gage manufacturing facilities.

Sixth. It would also prevent contractors bidding against each other and paying a premium to gage manufacturers for quick deliveries.

Seventh. Furnishing its own inspection gages and checking them at its own establishment, which has been fitted up to take care of this work with the latest up-to-date methods, and trained personnel insures uniformity and distribution to the best advantage.

Eighth. Instead of this being an added expense to the Government, it would be a saving, as the furnishing of gages would be taken into consideration when a contract is let.

Ninth. It would give uniform designs of gages and a more uniform gaging practice, having the whole program in mind, while the contractor is only concerned with his own individual problem.

The Gage Section of the Ordnance office is now giving and will give most of its attention to the preparation of gage lists for each component, with complete information as to the use, number of operations, etc., and to the improvement and redesign of gages made during the War when the lack of time did not permit sufficient thought to be spent on these problems. An idea of the magnitude of this work may be gained when we recall the number of gages required for some of the best known pieces of Ordnance equipment:

Springfield Rifle, Model 1903, requires 1,263 gages;
Browning Machine Gun, Model 1917, requires 2,262 gages;
75-mm. Gun Recuperator requires 597 gages;
155-mm. Howitzer and Recuperator requires 571 gages;
75-mm. Shell requires 77 gages;
155-mm. Shell requires 69 gages;
21-second Fuze requires 290 gages.

Tracings and prints must be made for each of these gages, involving a close study of the component itself, an intimate knowledge of the application of tolerances and allowances, the exercise of sound judgment in prescribing gage increment in order to give the manufacturer the benefit of all the tolerances prescribed on component drawing, and at the same time keep down the gage cost to a minimum by allowing a reasonable wear allowance on the gage.

In the 1925 appropriation $50,000 has been asked for the development of this work. Additional sums will be asked for from time to time as needed. A comparatively small sum spent on this important work when the country is at peace when more time can be given to these engineering studies, will, should an emergency arise, amply justify itself by more rapid production of munitions in time of war. It should be looked upon as an insurance whereby many lives may be saved, and perhaps may determine the ultimate outcome of a conflict.

The Ordnance Department has endeavored to solve its gage problem in the light of past experience—particularly the experience gained during the World War. To bring order out of confusion is next to impossible in war time: an army once routed is almost beyond hope. Even so with any component of it. And gages are no exception. Because such a contingency had not been planned for—I might even say, because the importance of gages was not realized or understood—there was obviously no reason why so complicated a problem should have solved itself.

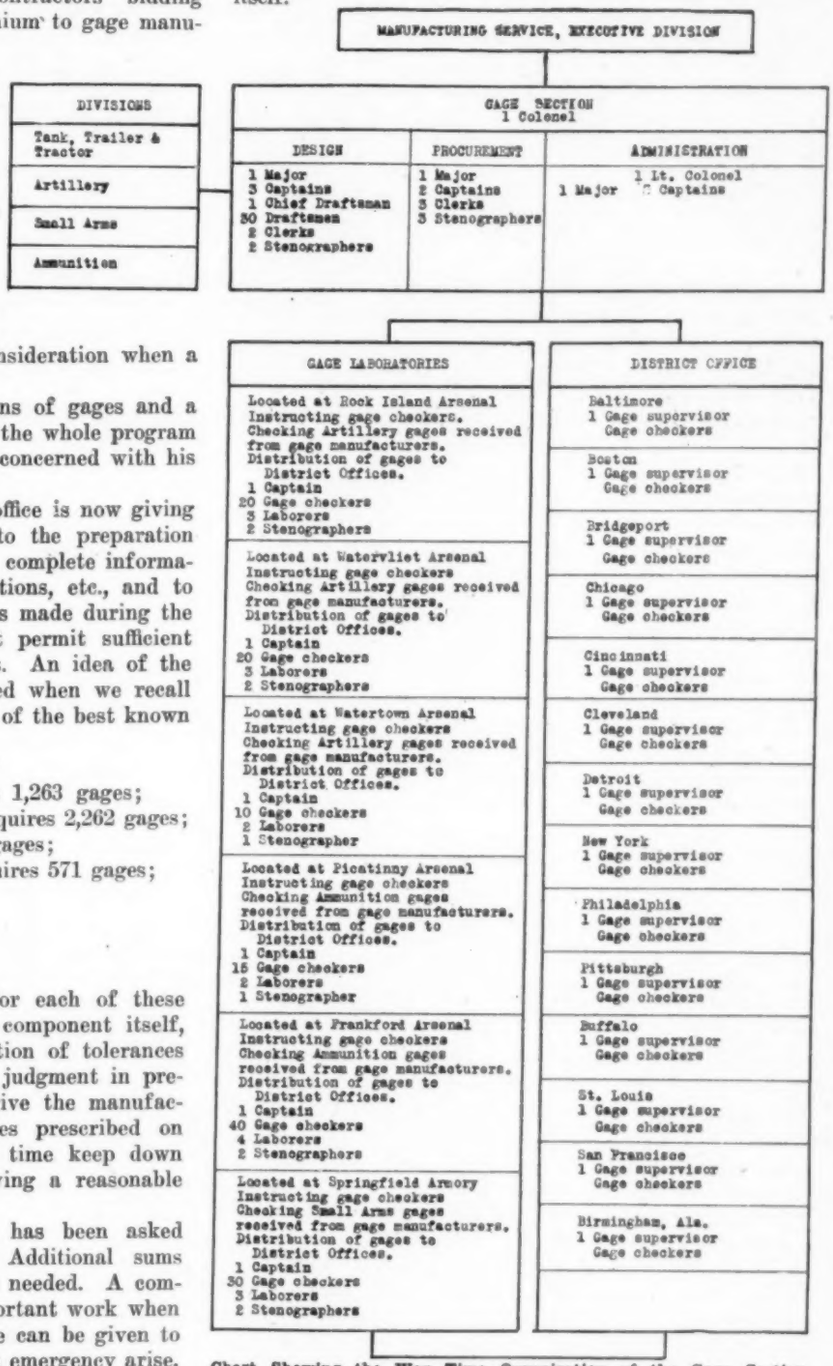


Chart Showing the War Time Organization of the Gage Section, Office of the Chief of Ordnance

Now the situation is different. With experience and time we have studied the problem in all its ramifications and we believe that the solution arrived at—if the necessary funds are provided from time to time to carry out the program—is an adequate guarantee that the gage situation will not hamper but will rather assure the quantity production of Ordnance whenever it shall be needed in the future.

Industrial Preparedness Plans Tested

New York Ordnance District Effects Rapid Mobilization on World War Anniversary

A GREAT stride toward effective industrial preparedness for the rapid and economical production of munitions in emergency was taken Sunday, April 6th, by the Reserve Army Officers assigned to the New York Ordnance District. They were called together by telegraphic test orders from Washington to test the mobilization plans worked out during the past winter under the direction of Hon. Dwight F. Davis, Assistant Secretary of War.

The occasion was the seventh anniversary of America's entry into the World War, and also marked the culmination of the winter's work of allocating War Orders, surveying plant facilities and preliminary negotiation of tentative war contracts within the metropolitan area of New York. The success which attended the initial test of plans for mobilization of industry for war indicates the possibility of setting aside April sixth each year as "Industrial Mobilization Day" in order to set a definite goal in point of time, when the year's progress can be checked up, and comparison made with the conditions of industrial unpreparedness which prevailed on April 6, 1917.

The mobilization plans were set in motion on receipt of a brief wire from Washington, reading:—

TESTINDMOB TELEGRAM 300 AM 4-6-24

Walsh, Chief, NYOD—Army Building

ASSECWAR directs INDMOBORD effective immediately Acknowledge—(Signed)—Williams CORDWAR

Translated into ordinary English, this cryptic "Test Industrial Mobilization" order informed (NYOD) the Chief of the New York Ordnance District that (ASSECWAR) the Assistant Secretary of War, charged under the National Defense Act with procurement of war munitions, had declared the (INDMOBORD) Industrial Mobilization Order, previously worked out in detail and filed there and in Washington, effective at once, this information being transmitted by CORDWAR, Major General C. C. Williams, Chief of Ordnance, War Department.

The District Mobilizes

Of course, this telegram had been received in the New York District Office some days prior to the mobilization and notices had been sent to each of the Reserve Officers attached to the District advising them of the mobilization and asking them to be present. Through arrangements made by Captain C. E. Davies, the eleventh floor of the Engineers Building at 33 West 39th Street had been loaned by the American Society of Mechanical Engineers for the day, and the offices arranged so that each division of the District was allotted definite headquarters.

At nine o'clock the Division Chiefs met with Colonel James L. Walsh for breakfast at the Engineers Club to discuss the day's plans. Besides Colonel Walsh there were present Lt. Colonels C. C. Goodrich, R. D. Coombs and F. C. Bull, Majors R. R. Harrison and J. J. O'Connell, and Captains C. E. Davies and H. W. Churchill.

Ordnance Reserve Officers began to arrive long before the appointed time, 10 A. M., and by 10.30 the last of those who had to rely upon the Sunday suburban trains had reported for duty. Many officers who were unable to present themselves in person telephoned or telegraphed their preparedness. Major Crosby Field, Chief of the Explosives Section, came back from Chicago, where he is spending a few weeks on business, to take charge of his section. In all, seventy-seven Ordnance Reserve Officers reported in response to the call.

Colonel H. B. Ferguson and Major Townsend Whelen, on duty in the Office of the Assistant Secretary of War in Washington, were among the first to arrive. Their presence was an inspiration to all officers present and the active part they played in outlining Ordnance progress and explaining the industrial preparedness plans was of very material importance.

Major H. B. Faber, Ord., O. R. C., with station in Washington, had volunteered his service and was one of the first to report. Major Faber is one of the leading experts in the country in pyrotechnics and he devoted his attention principally to the Explosives Section of the Ammunition Division in cooperation with Major Crosby Field, the Section Chief.

Immediately upon reporting for duty each officer joined his division and, under the direction of the Division Chief, started attacking the definite procurement and production problems that had been predetermined by the District Chief and his assistants. The entire morning was spent in solving these problems, the completion of details of organization and getting under way on the first day of wartime mobilization. Letters were written, telegrams dispatched, special messengers ordered to other eastern districts and arsenals to secure quick action on matters applying to them, officers assigned to manufacturers' plants, raw materials and gages and tools arranged for, and machinery manufacturers speeded up.

At one o'clock luncheon was served in the Engineers Club, which adjoins the Engineers Building, and promptly at two o'clock the afternoon session was called to order. This was a general assembly of all the divisions and the report of the morning's progress of each division was rendered. This session really took on the semblance of a daily progress consultation between the District Chief and his Division Chiefs as might be held in time of war.

Division Chiefs Report

Colonel R. D. Coombs, Chief of the Administration Division, made the first report, telling in a general way what the division had done. He stated that the Grand Central Palace, being the most readily secured of any building in the terminal zone, and most easily accessible from all parts of the District, had been taken over as a District headquarters. By application to the New York Telephone Company, the cooperation of that company was assured and a promise was secured that every telephone in the building would be connected and ready for use over its own trunk line within six hours; and further, it was promised that a four-position switch board would be installed and ready for uninterrupted service within four days. The Telephone Company assured the Communications Section that this equipment would be supplied in the allotted time in case of an emergency. Colonel Coombs then called upon Captain Carl T. Naumburg for the report of the Personnel Section and was advised of the present status of the reserve officer personnel of the District and of the plans, carefully worked out in cooperation with the Chief of the Second Civil Service District, whereby inspectors, stenographers, clerks and other civilian personnel would be secured. The Chiefs of the Property, Mail and Record, Disbursing and Shipping Sections, reported their progress. Captain Clarence N. Peacock reported on his survey of the source of supply of office equipment and was satisfied that no delay would be occasioned by lack of prompt procurement, reciting the offer of the New York Telephone Company to turn over to the Ordnance District very considerable office space in one of its centrally located buildings, completely equipped and furnished if the emergency arose.

Officers of New York Ordnance District Assembled for "Industrial Mobilization Day"

Seated, from left to right: Lieutenant Colonel R. D. Coombs, Chief Administration Division; Lieutenant Colonel C. C. Goodrich, Chief, Aircraft Armament Division; Captain H. W. Churchill, Executive Assistant to the Chief of the New York District; Colonel H. B. Ferguson, representing the Assistant Secretary of War; Col. James L. Walsh, Chief, New York Ordnance District; Major Townsend Whelen, Office of the Assistant Secretary of War; Lieutenant Colonel F. C. Bull, Chief, Ammunition Division; Major J. J. O'Connell, Chief, Small Arms Division, and Major R. R. Harrison, Chief, Artillery Division.

Colonel F. C. Bull, Chief of the Ammunition Division, rendered a report on the half million 75-mm. loaded complete rounds which constituted the problem assigned to his division. The details surrounding the procurement of the several components were recited; plans for securing necessary increased facilities, loading plants and proving grounds were explained; personnel and transportation were discussed. Major Crosby Field reported in greater detail on the loading arrangements and Captain C. E. Davies outlined the steps taken by the Metal Components Section of which he is Chief.

Major R. R. Harrison, Chief of the Artillery Division, reported on the progress of his division in negotiating for 75-mm. recoil mechanisms at the rate of one hundred per month, stipulating the sources of supply of the rough machined forgings, and discussing the best methods of production as they had been adopted by the prime contractor.

Colonel C. C. Goodrich, Chief of the Aircraft Armament Division, explained the details of procurement and entry into production concerning the 300-lb. demolition bombs with which his division is charged, and Major J. J. O'Connell outlined the methods adopted by the Small Arms Division, of which he is Chief, in securing 5,000,000 cores for the .30 caliber armor-piercing bullet, setting forth the details of manufacture as well as the source of supply of the bar stock, the problems of tools and gages, transportation, personnel, progress reports, etc.

Major Townsend Whelen, after congratulating the officers on the success of the test mobilization and proclaiming it "one of the most encouraging things so far done," outlined the plans under which the Office of the Assistant Secretary of War and the Office of the Chief of Ordnance have worked in connection with industrial preparedness.

Colonel Ferguson and Major Whelen had come from Washington as "official observers" of this test mobilization of the New York Ordnance District and Colonel Ferguson, in his address to the reserve officers, expressed his gratification in the result of the "call to the colors" and his intention of submitting a commendatory report to the Assistant Secretary.

At the close of the test, Colonel Walsh, Chief of the New York Ordnance District, thanked the officers for their part in "demonstrating the practicability of effective mobilization of industry for the production of implements of war, than which there is no surer guarantee of continued peace."

Pointing out that at the outbreak of war just seven years ago, there were only 97 officers of the Army skilled in the design and manufacture of Ordnance, whereas over 11,000 were needed to effect the equipment of our first 5,000,000 men, Colonel Walsh stated that, on account of this scarcity of available knowledge, it was not until we had been in the war a full year that it was possible to organize the New York Ordnance District on the basis contemplated today. "With the World War costing a million dollars an hour for two years," he stated, "we would have to save only 40 days in getting into production in order to save the government, which means ourselves, a billion dollars in a similar emergency." Continuing, he drew attention to the fact that "America is fortunately possessed of matchless reserves of man-

power in our 17,000,000 young men of military age; ample facilities for training them in the use of arms already exist in the shape of military schools, armories, training camps and rifle matches—all supported by the government; our natural resources furnish abundant reservoirs of raw material for conversion into munitions. But, however numerously and quickly we draft men to the colors, however we organize them into tactical units, however well we house them and feed them and clothe them, however efficiently we transport them by motor, rail or water, however generously we pay them, the fact remains that men are not soldiers until we put in their hands the tools of their trade—Ordnance. The World War proved that all other preparations for waging war can be made faster than the necessary Ordnance can be produced, and this highly specialized non-commercial equipment must necessarily be completed before training in its employment can even be commenced.

"The Ordnance Department under General Williams has determined what types of ordnance shall be put into production in the event of war, the War Department, under the Assistant Secretary of War, Mr. Davis, has determined how many of each type will be needed and when. It's up to us to determine here in New York who's going to make what—and when we can promise to deliver the goods. The manufacture of ordnance of satisfactory quality in sufficient quantity and within a reasonable time is the crux of thhe whole problem of preparedness. Until a satisfactory solution is arrived at, all other preparations for war are futile and beside the point.

"The work you gentlemen are doing is, therefore, of vital importance. Even if you only 'walk through the plays' as you have done today, and learn the signals, as it were, you have the satisfaction of knowing that you are driving home the appalling need for a better and fuller appreciation of the fundamental importance of adequate munition power, without which our man-power is of little avail."

It was the unanimous consensus of opinion of all those present that the New York Ordnance District should again assemble in a similar test on April 6, 1925, regardless of any mobilizations that might take place in the meantime. Every officer who reported for duty and worked throughout the day in this test of the results of the work of the District appeared to be profoundly interested in the problems put up to him to solve—surely a most reliable prediction of the ultimate success of the industrial preparedness work that must be carried out by the Ordnance Reserve Officers attached to the District Offices.

Praise From the Press

All the leading New York papers covered this test mobilization and commented very favorably on the Ordnance Department plans embodying the industrial preparedness side of our national defense in their issues of Monday, April 7.

Under the caption "Industry Answers Call to Arms—Experiment So Successful That Nation-Wide Test Will Be Held in September," the *New York Times* says—"A totally new type of sham warfare was held in this city yesterday in observing the seventh anniversary of America's declaration of war on Germany. A mimic industrial mobilization of the East took place under the direction of the Ordnance District Chief. News of a declaration of war against Brobdingnag & Erewhon was flashed over the wire from Washington to the District Chief, who hurried to his office in the Engineers Building. The first thing he did was to waken Guy E. Tripp, head of the Westinghouse Electric and Manufacturing Company, and order him to drop work on radio sets and set all his factories to filling war contracts that had been signed in advance."

The *New York Tribune* printed a photograph of the assemblage and in an article on another page ran a half column covering the test, under the heading "Reserves Insure Full Supplies in Case of War." Under the headlines "City is Made Ready For War," the *New York American* gave over an entire column to the meeting, saying, in fact, "What they (the Federal authorities) wanted to find out in Washington was how soon New York could get on a war basis."

While the newspaper accounts were in all cases optimistic as to actual results achieved, the reserve officers who attended the test were in no wise misled into thinking that the problem had been solved completely. The real accomplishment consisted of giving all concerned a pretty fair picture of what they would be up against in time of war. In addition, it was demonstrated beyond question that a certain amount of very valuable training could be given officers assigned to the Districts through placing before them concrete problems such as would confront them in the event of hostilities. Over and above all this was the great enthusiasm and interest aroused throughout the District, a factor which cannot be neglected in appraising the value of this sort of test. Publicity of itself is of little value in solving the tremendous problems which confront the Ordnance Districts, but it does bring to their assistance men who have the qualifications to take an active part in overcoming difficulties. For the next year at least, it is probable that one of the major objectives in each District will be to maintain the interest of officers already assigned and arouse the interest of others who can be brought into the Reserve Corps and placed to advantage in the organization. From this viewpoint it is felt that "Mobilization Day" was a very decided success. Many reserve officers called at the District Office prior to the test in order to acquaint themselves with their duties and this increased interest, so manifested, is indicative of the progress being made with the Reserves. Officers assigned to divisions and sections got better acquainted with each other and familiarized themselves in the District Organization, and many constructive suggestions have come from these informal group meetings. Those officers who took part have merited the thanks of the District Chief and of the Department and the fact of his attendance and interest have been noted on the personal record of each.

Those who reported were:—

District Chief:—Colonel James L. Walsh.

Administration Division:—Lt. Colonel R. D. Coombs, Captain A. W. Coombs (Tel.), Captain Wm. H. Milholland, Captain Carl T. Naumburg, Captain C. N. Peacock, Captain F. R. Slater, Captain S. A. Wade—(Wire), Captain G. O. Walton, 1st Lt. Wm. F. Connelly, 1st Lt. J. L. Delius, 2nd Lt. Seymour Brown.

Aircraft Armament Division:—Lt. Colonel C. C. Goodrich, 1st Lt. E. M. Florcyk, 1st Lt. F. C. Gatje—(Tel.), 2nd Lt. J. E. Brown, 2nd Lt. Jas. R. Haptonstall, 2nd Lt. Chas. S. Smith, 2nd Lt. Walter V. Walsh—(Tel.)

Ammunition Division:—Lt. Colonel F. C. Bull, Major Crosby Field, Major Chas. E. Sholes—(Wire), Captain Howard Corlies—(Tel.), Captain C. E. Davies, Captain

(Continued on page 408)

Bombs

PART III

By

WILLIAM A. BORDEN

GAS BOMBS have never reached the stage where they could be considered entirely satisfactory for use. They have been experimented with to a limited extent both in the United States and abroad with a view of being prepared to retaliate if gas bombs were ever used by an enemy. Gas is no discriminator of persons, and, should it be used in areas inhabited by non-combatants as well as combatants, it would act likewise against both. Its use, therefore, in such places is contrary to the laws of warfare as recognized by civilized nations. So far as is known, gas was not used in bombs in the World War. Its use in them should certainly never be initiated by any country in the attack of areas in which non-combatants are present. No further development of gas bombs can be expected as long as the present treaty agreement on the use of gas is in force.

Smoke Bombs

Smoke bombs are designed to produce some form of smoke cloud, depending upon the type of bomb used. Tactical requirements call for bombs to produce smoke screens on water and on land. There is also some likelihood that the formation of smoke clouds in the air may be required. The smoke screen on water is needed to hide attacking aircraft from their naval targets, so that they may come in close and not be observed. This is particularly necessary when a torpedo attack is launched by aircraft against naval vessels. Ground screens are needed to shield attacking aircraft, also to protect troops and hide their movements from the enemy. It may develop that smoke screens in the air will afford protection to attacking aircraft, especially interfering with hostile antiaircraft fire.

The development of a special type of smoke, or "beacon" bomb, which will give off smoke and flame when dropped on water, has been suggested. The smoke given off should be visible during the day and the flame during the night. An airplane or airship navigating over water might use this bomb as a beacon by which to verify its course or as a guide to aircraft.

A very good smoke producing chemical for use in bombs is titanium tetrachloride. It is a liquid and is scattered on impact by a small bursting charge It produces an instantaneous white cloud which is sufficiently opaque to obscure vision. A nose fuze which will cause the bomb to function at, or slightly above, the surface of the ground is required.

White phosphorous, although an excellent smoke producing chemical and used in certain projectiles for the production of smoke clouds, is considered dangerous as a bomb filler.

A chemical mixture of zinc dust, hexachlorephone and other minor constituents known as HC mixture, has been developed which, when burning, gives off a dense white smoke. A bomb designed to use this chemical does not burst on impact and scatter the chemical, but permits it to burn in the case. The smoke produced issues from the bomb in great volume and is drifted away by the wind, forming a very effective cloud.

The type of smoke bomb developed for producing a smoke screen over water employs this chemical mixture. It is designed to float on water, permitting the smoke to be evolved as it floats. The initiation of the smoke in this bomb is delayed a few seconds to permit the bomb after impact to rise to the surface of the water. The mixture then burns for several minutes, producing a very effective smoke screen.

The production of a smoke cloud on land by the use of bombs has received some consideration. Bombs constructed on the principle of the 8-oz. scatter-type incendiary bomb replacing the incendiary charge by a smoke charge have been tried. Other bombs containing a greater volume of smoke-producing chemical to give an instantaneous cloud have been tested.

A bomb similar to the floating type smoke bomb, but developed to produce smoke screens on the ground, may be effective, as the smoke can be evolved for a period of several minutes and in great volume. A retarding device would of necessity have to be incorporated in the design of such a bomb to keep down its striking velocity, so as to prevent penetration into the ground. Considerable study and tests are required to perfect a smoke bomb of this type, and there is some question as to the real necessity for such. Certainly for areas within the range of artillery fire, it is very doubtful if a smoke screen can be laid down by aircraft as efficiently as it can be done by artillery.

Some form of time fuze is required for those bombs designed to produce a smoke screen in the air. The fuze must operate so that the bomb will function at a predetermined distance below the aircraft. Here

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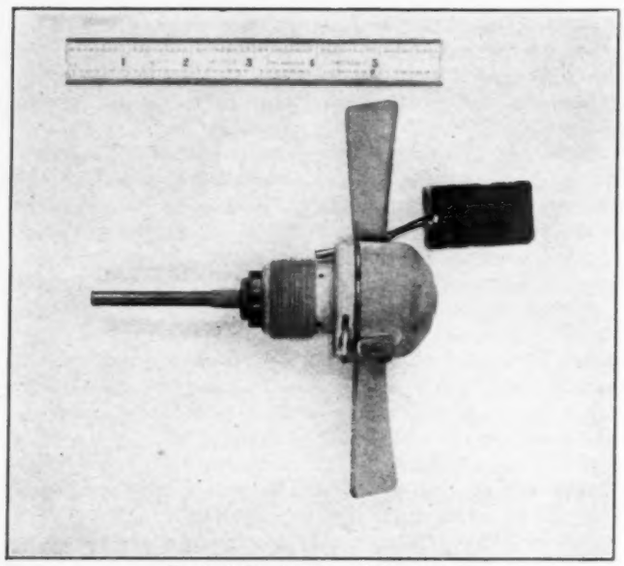
Smoke Screen from Navy Smoke Bombs

Screen produced to hide simulated airplane torpedo attack in maneuvers against ex-S. S. Alabama

again there is need for investigation both as to the actual requirement for such a bomb and the development of a bomb and fuze to produce the result desired.

Smoke bombs are purely defensive devices and for this reason alone it is necessary that careful consideration be given to their use so that they will not unnecessarily replace any of the bombs which are offensive and destructive in character.



Typical Bomb Fuze—Assembled

Note cylinders showing under rim of cup which are between the plate and housing of the fuze. The split pin is in place to keep the cup from unscrewing. The primer detonator is assembled to the fuze.

Little has been done on the beacon bomb. It probably will develop along the lines of the floating type smoke bomb, and, instead of merely giving off smoke, will, in addition, give off some form of light. The Germans developed such a bomb to assist them in navigating their Zeppelins over water.

Practice Bombs

Practice bombs are standard service type bombs with the regular charge replaced by an inexpensive loading charge. They are used in the training of Air Service troops. The practice loading permits service type fuzes to be used so that training may be had in fuzing as well as in handling the service type bombs. The loading is so designed that when the bomb functions, it gives a smoke burst in the day time and a flash at night visible to the observer in the aircraft at the maximum altitude from which the bomb may be dropped. A practice loading using standard loaded fuzes and boosters with a small charge of black powder has given very good results. The remaining cavity of the bomb is filled with sand. The black powder is loaded in bags, which can be inserted in the nose or tail opening in the bomb. Empty bombs, loaded fuzes, loaded boosters, and powder charges are issued, and the practice bombs made up wherever they are to be used.

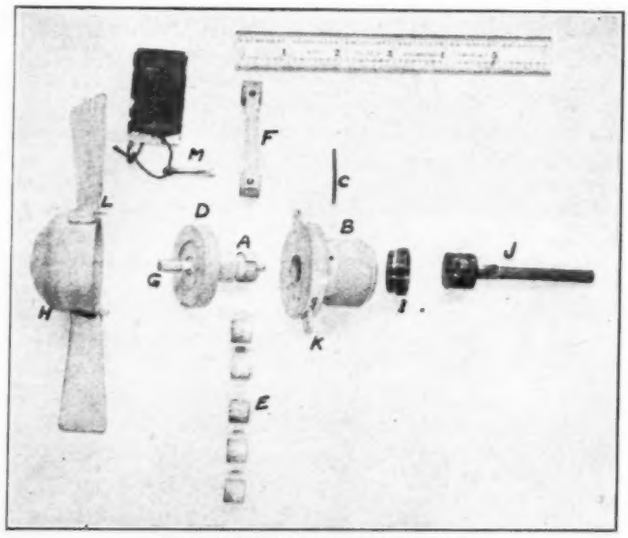
The term "dummy" is given to any bomb which is unloaded, and such bombs are plainly marked "dummy" to prevent their being confused with loaded ones.

Bomb Fuzes

All bombs require some form of fuze to cause them to function. These are of different types, depending upon the action desired. As nearly all bombs are equipped with two fuzes, one in the nose and the other in the tail, the general classification divides them into nose and tail types. Of these, the ones usually used function mechanically on impact, firing a primer, which initiates a detonating train, resulting in the detonation of the main charge of the bomb.

All fuzes must be designed to permit a fuzed bomb to be carried safely in aircraft and to be armed only after the bomb has been dropped. It must be so designed that if it is desired to drop the bomb "safe," the fuze may be kept from arming and must then be so safe that the forces of impact will not cause it to function.

The general design of the nose fuze provides a firing pin passing through a housing with a shear pin passing through it and the housing, holding it in place. A plate is fastened on the outer end of the pin which protrudes from the housing. Between this plate and the housing are metal discs, which prevent the plate and firing pin from being forced to the rear. The discs are held under the plate by a cup to which are attached two wind vanes. The cup is screwed loosely to the end of the firing pin protruding in front of the plate. When the bomb is dropped, the rush of air past the bomb acts on the wind vane, unscrewing the cup. A spring acting on the discs throws them out from under the plate. There is then nothing except the shear wire to prevent the firing pin from being driven to the rear when the plate strikes the ground. On impact, the plate and firing pin are retarded and the bomb continuing forward shears the shear wire. The primer in rear of the fuze housing being carried forward by the bomb, strikes the firing pin and is fired and flashes into a detonator, or ignites a powder delay train if there be a delay, which in turn flashes into the detonator.



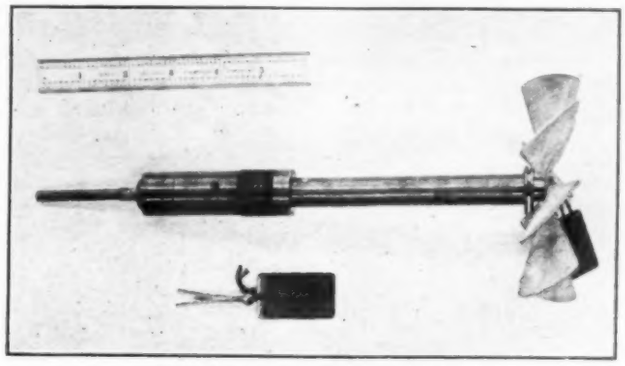
Typical Bomb Fuze—Disassembled

The firing pin (A) assembles in the housing (B) being held in place by the shear pin (C). A plate (D) is rigidly attached to the firing-pin with a space between it and the housing in which the cylinders (E) and (F), these latter, being connected by a flat spring, are held by the cup (H). This screws on to the threaded portion (G) of the firing-pin, the sides of the cup passing over the plate and cylinders. To it are attached two wind vanes which are kept from turning during shipment by the split pin (M) passing through a hole in a flanged piece (K) assembled to the housing. The primer detonator (J), with a primer at the forward end, is assembled to the fuze by the threaded collar (I).

The detonator, which is fitted into a well in the booster of the bomb, acts on the booster, which in turn detonates the main charge.

While on the airplane the wind vane is prevented from

turning by a wire which passes through an eye attached to the housing, and through a hole in one of the wind vanes. This wire, called the arming wire, is retained by an arming device on the bomb rack, if it is desired that the fuze should arm, and strips out of the fuze as the bomb drops from the rack. The wind vane is then free and is spun off as the bomb falls. In the case of safe dropping, however, the arming device on the rack permits the arming wire to fall with the bomb, and it does not strip out of the fuze. The discs, therefore, are retained under the plate by the cup and on impact the plate and firing pin are prevented from moving, and the primer is not struck.



Typical Bomb Tail Fuze—Assembled

One of the split pins provided for safety has been removed from the housing. The hole through the striker weight can be seen through the hole in the housing. The split pin through the wind vane is in place to prevent the vane and shaft from unscrewing. The primer detonator is assembled to the fuze.

In the usual form of tail fuze the firing pin is attached to a striker weight. The striker weight slides in a housing and is kept in a rear position, so that the firing pin is held from the primer by a threaded shaft which screws through the housing and into the rear end of the striker weight. A spiral spring is also interposed between the forward end of the striker weight and primer. A wind vane is attached to the shaft and is held from turning while the bomb is on the rack in the airplane, by an arming wire which passes through a hole in a shoulder of the fuze housing and through the wind vane. If it is desired to drop the bomb to arm, the arming wire is retained by the rack and strips out of the fuze, as the bomb drops clear from the rack. The rush of air by the bomb turns the wind vane, unscrewing the shaft out of the striker weight and fuze housing. The striker weight is thus freed, being restrained from forward movement by the spring only. On impact the bomb is retarded, the striker weight continues forward compressing the spring and the primer is fired when struck by the firing pin.

For safe dropping the arming wire is dropped with the bomb and keeps the wind vane from turning. Thus the striker weight is locked to the housing and on impact can not move forward. Therefore, the firing pin can not strike the primer.

Nearly all fuzes are armed through the use of a wind vane as described. The German fuzes are notable exceptions, being armed by centrifugal force. The fins of the bomb are helical and cause it to spin in flight, this rotation producing the action which arms the fuze.

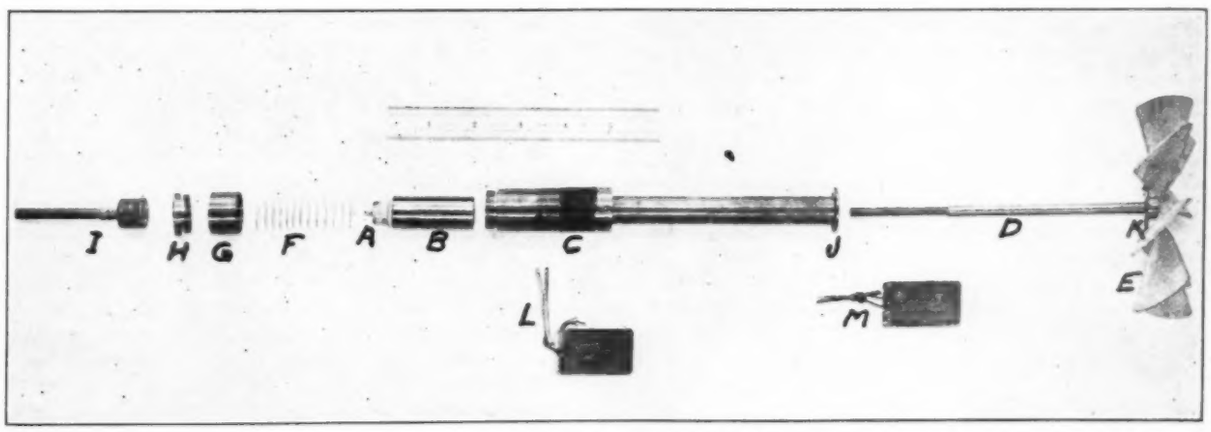
The general service fuze permits the insertion of various delays, depending upon the action desired. Where the bomb should function immediately on impact, instantaneous elements are used. If penetration is wanted, a delay must be employed.

The length of the delay used depends upon the target to be attacked. For penetrating roofs of factories a delay as short as one-twentieth of a second will permit the bomb to penetrate to the lower floors before detonation occurs. For antisubmarine attack a delay of about a second will insure that the bomb will penetrate well under the surface so as to obtain a good mining effect and reach a submarine which may be fairly deep. A special delay of about fifteen seconds duration is apparently required to permit aircraft to drop a bomb and to get a sufficient distance away to escape the blast or fragments from the bomb. This delay is used only in large bombs when they are dropped from very low altitudes, as may occur in night bombing.

Special Bomb Fuzes

The need for certain special fuzes for bombs has been indicated by tactical requirements.

Fuzes which will give either instantaneous or delay action,

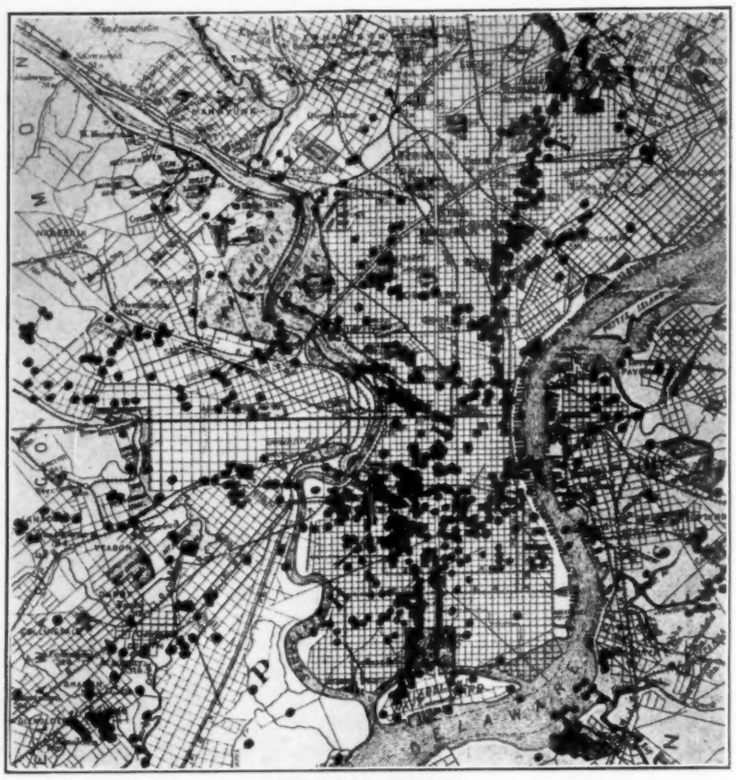


A Typical Bomb Tail Fuze—Disassembled

A firing pin (A) is fastened to a striker weight (B) which slides in a housing (C). It is held to the rear in the housing by a spring (F) and is locked there when safe by a shaft (D) on one end of which are threads which screw through the housing and into the striker weight. The spring is held in the housing by the special nut (G), which is screwed on the end of the housing. A wind vane (E) is rigidly attached to the end of the shaft. The shaft and wind vane, when screwed into the housing and striker weight, are prevented from turning during shipment by the split pin (M), which passes through a hole in the flange (J) on the housing and holes through the flange of the nut (K) and wind vane. To insure that the striker weight is in a safe position for assembly and shipment, a hole is provided through the housing and striker weight through which the split pin (L) is assembled. The primer detonator (I) is held to the end of the fuze by the threaded collar (H).

depending upon the nature of the medium struck, are required. For instance, in bombing submarines or certain naval targets with demolition or antisubmarine bombs, it would be very desirable to have instantaneous action if a direct hit were made and delay action if a near hit were made. In the case of a direct hit, these bombs, to be effective, must function instantaneously before they are broken up by impact on the resisting surfaces of ships, as they will not pentrate armor. When a near hit is made, a mining effect must be obtained, which requires that detonation of the bomb be delayed to permit penetration well below the surface of the water.

As demolition bombs are made only sufficiently strong to penetrate the average warehouse or factory roof, they would break up, no doubt, if they struck a more resisting surface, and no detonation, or a low order detonation, would result. Therefore, if the fuze would delay action on the roof of the factory building, permitting penetration, and would give instantaneous action on a stronger surface, the maximum effective operation of the bomb would be obtained.



Philadelphia Bombed!

Points of impact of bombs dropped on London during the World War plotted on a map of Philadelphia. During the London air raids over 800 bombs were dropped, killing 500 people and wounding about 1,500. In one raid alone over £1,500,000 damage was done

During the war technical requirements called for the dropping of bombs upon water from an altitude of a few hundred feet, as in the attack upon the mole at Zeebrugge. As impact was often on water, a fuze was required which would function even though the impact might not be sufficient to force a firing pin against a primer, as is usually done in the ordinary fuze. Such a fuze was developed and consisted of a firing pin actuated by a spring. The pin was released by a wind vane after the bomb had fallen some distance below the airplane and struck a primer. The primer ignited a delay of sufficient length to permit the airplane to reach a safe distance before the bomb detonated. The bomb, in the meantime, reached its target, the delay continuing beyond the time of impact until the airplane was safely away.

Long Delay Bomb Fuze

Another important type of fuze, which is called for in certain instances by tactical requirements, is the long delay fuze. This fuze gives a delay of several hours but may be set for shorter lengths of time. It is used in bombs dropped against canal locks, docks, breakwaters and similar targets. Bombs set at various delays are dropped and function at various times. Their purpose is to destroy the target attacked and prevent repair, for of course, divers would not undertake such work with the likelihood of a bomb already dropped going off at any time. The same fuzes would also be used in bombs dropped on a town or city evacuated by friendly troops, their functioning being delayed sufficiently so that detonation would occur sometime after the place was occupied by the hostile force. These fuzes are so constructed that should attempt be made to unfuze the bombs, they would immediately function and detonate the bomb.

The "all-ways" fuze has been referred to in the description of the aerial torpedo. Such a fuze is constructed so that it will function and cause detonation regardless of the position of the bomb when it strikes. Other fuzes will generally function only when the bomb strikes point on.

A time fuze which will cause the detonation of a bomb at a predetermined distance below the aircraft from which the bomb is dropped, is needed for the antiaircraft bomb, for certain aircraft pyrotechnic flares, and for smoke bombs for air burst. Such a fuze employs a powder or mechanical time delay which is fired or set in motion after the bomb has fallen free from the rack on the aircraft. The ideal fuze would be one which could be set during flight while the bomb is on the rack, but present practicable considerations require the fuze to be set when the bombs are loaded on the racks for use on a flight.

The tactical employment of bombs and their possible effect on military strategy is to a certain extent problematical. In the early days of the World War, bombing was undertaken without serious opposition. Then antiaircraft weapons and combat aircraft came into play and interfered very considerably with bombing missions. It appears that during the war there were many cases where bombing operations were carried out in rather an unsystematic manner, and without being co-ordinated in the general scheme of military operations. At present, as may be expected during a time of peace, the exponents of antiaircraft artillery make very great claims as to the effectiveness of the protection afforded by their weapons, while enthusiastic bombers, on the other hand, are positive that aircraft will reach its objective and produce great damage with bombs despite antiaircraft opposition.

It is known that in the past war the Germans succeeded

(Continued on page 408)

The Influence of Density of Packing Upon Explosibility of Ammonium Nitrate*

By

J. L. SHERRICK

THE work herein reported represents the third phase of the general investigation on the explosibility of ammonium nitrate conducted under the direction of the National Research Council Committee on the Investigation of the Explosibility of Ammonium Compounds.

That the density of packing would influence the sensitiveness of ammonium nitrate to detonation was indicated by the fact that explosives containing large proportions (80 per cent) of this salt become insensitive if pressed to high densities.[1] Kast[2] has likewise shown that, for Monachit, consisting of 81 per cent ammonium nitrate, 13 per cent liquid nitro-derivatives of xylol, 5 per cent potassium nitrate, and 1 per cent flour, the tendency for the rate of detonation to decrease as it proceeds from the source is greater with greater densities.

Influence of density upon the constancy of rate of detonation of Monachit

Density	Rate of detonation in section, m/s 150-250 mm.	250-630 mm.	630-730 mm.	Initiators
1.02	4885	4440	3345	2 gram detonator
1.35	4230	3495	3135	2 gram detonator + 140 grams TNT
1.56	4745	1730	1270	2 gram detonator + 127 grams TNT

Materials Used in the Investigation

Since the course of the decomposition of ammonium nitrate is influenced by impurities, it was deemed advisable to use a good grade of industrial nitrate as representative of the large quantities handled in storage and transportation in the industries.

Ammonium nitrate.—This was "B. A. S. F. 550" ammonium nitrate contributed by the Hercules Powder Co. It analyzed as follows.

Constituents	Per Cent
Moisture	1.20
Insoluble matter	0.097
Ammonium chloride	0.024
Sulphates	None
Nitrites	None

Its physical characteristics were found to be: color, buff; consistency—granular, coarse, wet, brittle particles, slightly cohesive; shaking density,[3] 0.71.

Military explosives used as boosters.—The general characteristics of these boosters, which were definite chemical compounds, are shown in Table 1.

Amatol 80:20.—This was from a lot which had been melted and cast without stirring. There was considerable variation in the different portions of the cast, as shown by the following figures taken from eight analyses:

Constituent	Variation, per cent	Average, per cent
Moisture	0.04 to 0.06	0.05
Ammonium nitrate	71.30 to 83.19	79.95
TNT	16.76 to 28.64	20.00

As the cast was broken up and thoroughly mixed, the average values represent fairly accurately the composition of the material used. Its shaking density was 1.00.

60 per cent gelantine dynamite.—The analysis of this gave the following:

Constituent	Per cent
Moisture	0.59
Nitroglycerine, Nitropolyglycerine, TNT	50.10
Sodium nitrate	35.35
Calcium carbonate	1.20
Sulphur	0.70
Nitrocellulose	1.51
Carbonaceous combustible material	10.55

Its apparent specific gravity in cartridge form was 1.62.

40 per cent ammonia dynamite.—The analysis of this gave the following:

Constituent	Per cent
Moisture	1.06
Nitroglycerine and nitropolyglycerin	21.46
Sodium nitrate	36.33
Ammonium nitrate	27.38
Sulphur	0.60
Calcium carbonate	1.35
Carbonaceous combustible material	11.82

Its apparent specific gravity, cartridged, was 1.19.

*Report IV of the Committee on the Investigation of the Explosibility of Ammonium Compounds, National Research Council, conducted in cooperation with the Bureau of Mines. Published by permission of the Director, Bureau of Mines. Report I of this series, "The Explosibility of Ammonium Nitrate," by Dr. Chas. E. Munroe, was published in Chem. and Met. Eng. Vol. 26, 1922, pp. 536-542. Report II, "Fire Risks With Ammonium Nitrate," by Dr. J. L. Sherrick, was published in ARMY ORDNANCE, Vol. IV, 1924, pp. 237-241. Report III, "The Influence of Confinement Upon Explosibility of Ammonium Nitrate," by Dr. J. L. Sherrick, was published in ARMY ORDNANCE, Vol. IV, 1924, pp. 329-333. Report IV, herewith, concludes the series for the present. The committee will issue additional reports from time to time. These will be published in ARMY ORDNANCE as, and when, they are issued.

1 N. W. Berger, Spreng-und Schiesversuche mit brisanten Sprengstoffen in Norwegen; Zeit fur das ges. Schiess-und Sprengstoffwesen, vol. 1, 1906, p. 150.

2 H. Kast, Die Brisanzbestimmung und die Messung der Detonations geschwindigkeit von Sprengstoffen; Zeit für das ges. Schiess- und Sprengstoffwesen, vol. 8, 1913, pp. 133-136.

3 The shaking density of any explosive material is determined at the Bureau of Mines Explosives Experiment Station at Bruceton, Pa., by the use of an apparatus which consists of a piece of Shelby tube 1¼ inch inside diameter, 1⅝ inch outside diameter, and 12 inches inside length, with a pipe cap on one end; a frame which allows the tube to be raised just 2 inches, thereby securing a constant height of drop for shaking the tube; and a small plunger which measures the depth to which the explosive has sunk after shaking. The base of the shaking frame is a piece of oak 2 inches thick and rests on a Trauzl lead block or other non-resilient material. The tube is filled to the top with the material under test. If the material does not flow freely, the tube may be gently tapped to fill it. The tube is then placed in the frame and continually dropped from the 2-inch height until the surface of the explosive no longer sinks by continued shaking. The volume and weight relation gives the shaking density.

TABLE 1.—Characteristics and Analysis of Military Explosives

Explosive	Melting point, ° C.	Solidification point, ° C.	Moisture, per cent	Insoluble matter, per cent	Acidity, per cent	Ash, per cent	Sulphuric acid (free and combined) per cent	Nitrogen per cent	Shaking density
Grade I TNT	----	80.2	----	----	----	----	----	18.14	0.96
Picric acid	----	121.06	0.64	0.031	----	0.018	0.28	18.17	0.93
Tetryl	128.9	---	0.03	0.24	0.00	0.08	---	----	0.99
TNA	213.2	---	0.13	0.58	0.05	0.23	---	----	0.82

High-content ammonium-nitrate explosives.—The analysis of this gave the following:

Constituent	Per cent
Moisture	0.49
Nitroglycerine and nitropolyglycerin	9.02
Ammonium nitrate	78.12
Sodium nitrate	2.23
Calcium carbonate	0.98
Carbonaceous combustible material	9.16

Its apparent specific gravity, cartridged, was 1.01.

Ammonium sulphate.—This was the c. p. analyzed material from the Baker & Adamson Co. Its shaking density was 0.97.

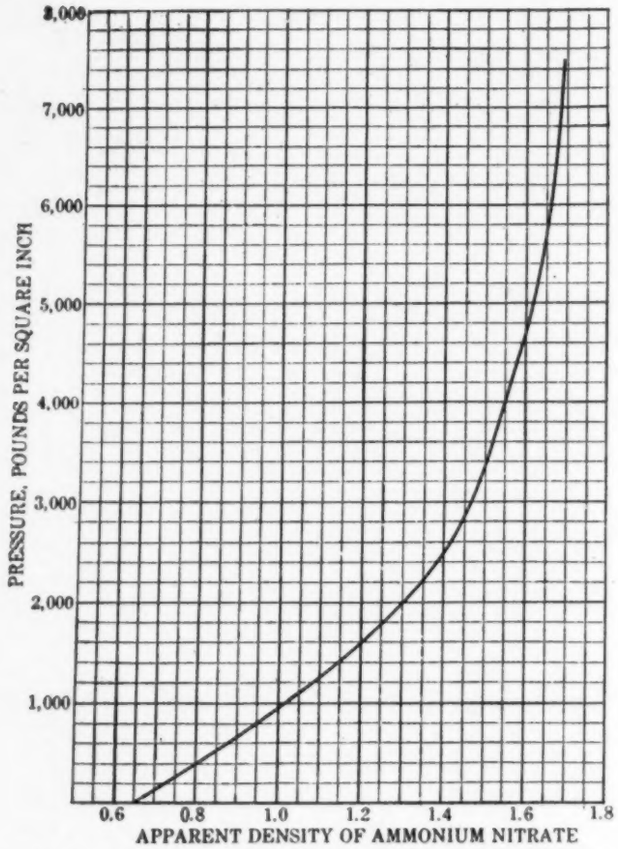


Fig. 1. Compression of Ammonium Nitrate Masses (M-3066)

Electric detonators.—No. 8 electric detonators were used. These contained approximately a 2-gram charge of a mixture of 80 per cent fulminate of mercury and 20 per cent of potassium chlorate.

Density of Ammonium Nitrate Charges

The various densities were attained by forcing a steel plunger into the Shelby tubes, containing the ammonium nitrate charges, by means of a hydraulic press. The pressure required for attaining a given density of ammonium nitrate varied to some extent with the period of application of such pressure. In this work the pressure was brought rapidly to the point desired and held for about thirty seconds. Figure 1 shows the pressures necessary for attaining the various densities. The charges were pressed in 33⅓-gram increments.

Experimental Procedure

Ammonium nitrate which had been stored for several days at room temperature (20° C.) was pressed into the Shelby tubing in three 33⅓-gram increments, and the density of packing determined by measurement. The booster was then packed directly on top of the ammonium nitrate charge at the normal shaking density for the booster used. The final assembly was that given in Figure 2. The charge was fired shortly after packing, so that there was no time allowed for caking or re-crystallization of the salt.

Effect of Density of Ammonium Nitrate Charge Upon the Compression of Small Lead Blocks

In the earlier work the results indicated that TNA was one of the most efficient boosters for ammonium nitrate, and amatol 80/20 was one of the least efficient. These two explosives were therefore selected as the boosters for use in the tests. As previous work had proved a 50-gram booster charge to be fully as effective as larger amounts, this quantity of booster was used in all tests.

The results are shown graphically in Figures 3 and 4. Curves *a* are for 1/16-inch wall Shelby tube confinement,

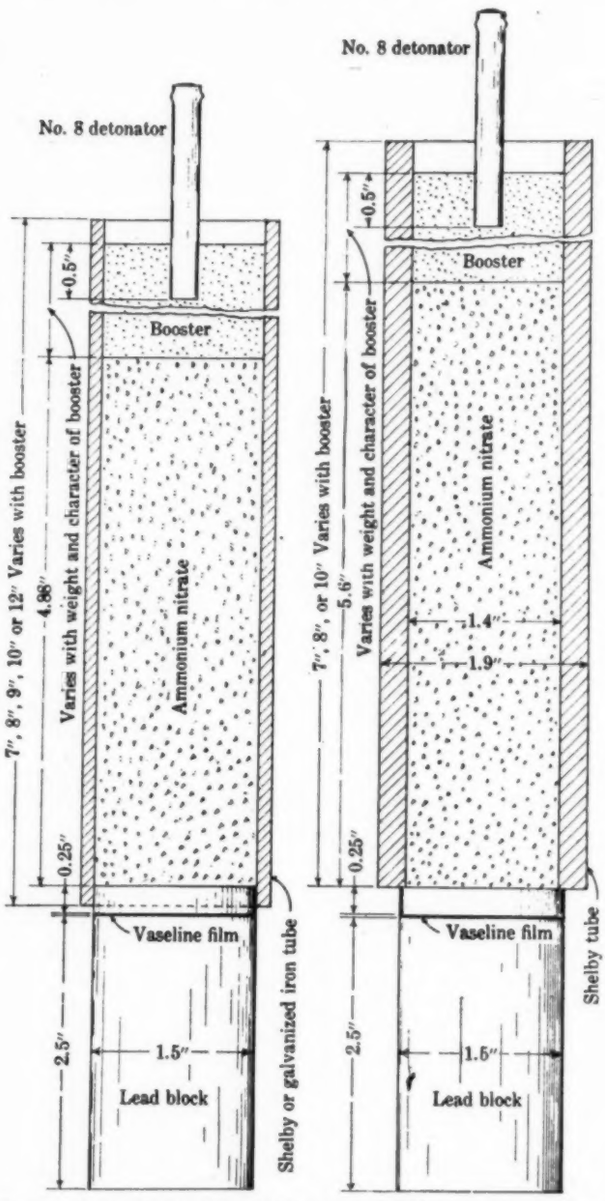


Fig. 2. Arrangement of Explosive, Shelby Tubing, and Lead Block for Tests on Explosibility of Ammonium Nitrate

curves *b* for ⅛-inch wall, and curves *c* for ¼-inch wall. All of these curves show a pronounced minimum in the compression values, and the density at which the minimum occurs seems to depend more upon the confinement than upon the nature of the booster used. The possible occurrence of a pronounced break in the curve is indicated for 1/16 and ¼-inch wall tube confinement and for ⅛-inch wall confinement with TNA booster but for the ⅛-inch wall confinement with amatol 80/20 booster this is not the case. The rise in compression values with increasing density for values of the density greater than that of the minimum point may be explained by the fact that, assuming no explosion of the ammonium nitrate as taking place, the booster charge is nearer to the lead block the greater the density of the nitrate charge and, hence, has a relatively greater effect. If no explosion of the ammonium nitrate took place at any density we might expect the compression of the block to increase regularly

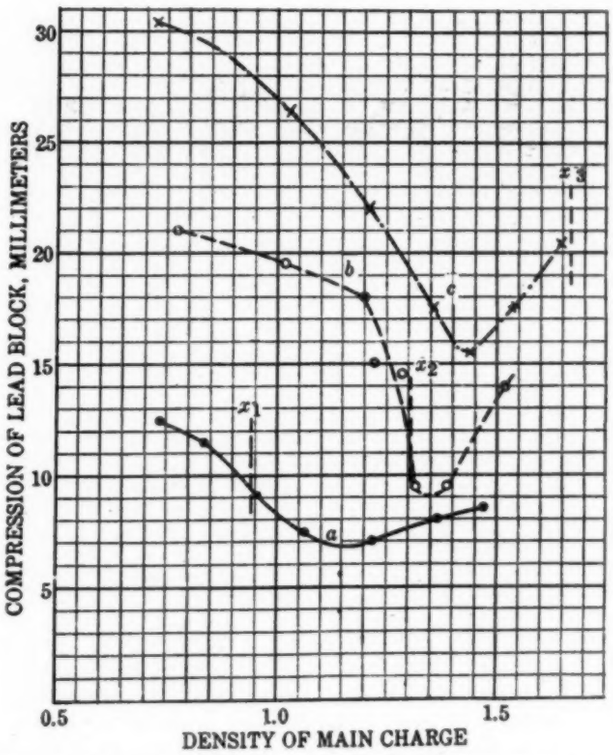


Fig. 3. Compression of Small Lead Blocks by 100 Grams of Ammonium Nitrate With 50 Grams of TNA as booster. Variation of Ammonium Nitrate Densities, and Confinement of Charge.

as the booster charge approached closer to the lead block, or as the density increased. That this is not the case may, however, be shown by results of tests with non-explosive or inert salts.

Effect of Density of Inert Salts Upon the Transmission of the Compression Wave From the Booster

In our earlier work we used ammonium sulphate as a blank in an attempt to separate the compression effects of the booster charge and the main ammonium nitrate charge. As the shaking density of the ammonium sulphate was 0.97 compared with 0.71 for the ammonium nitrate, 137 grams or an equivalent volume of ammonium sulphate was used. Since in the later series of tests it was possible to make comparisons of the same weight (100 grams)

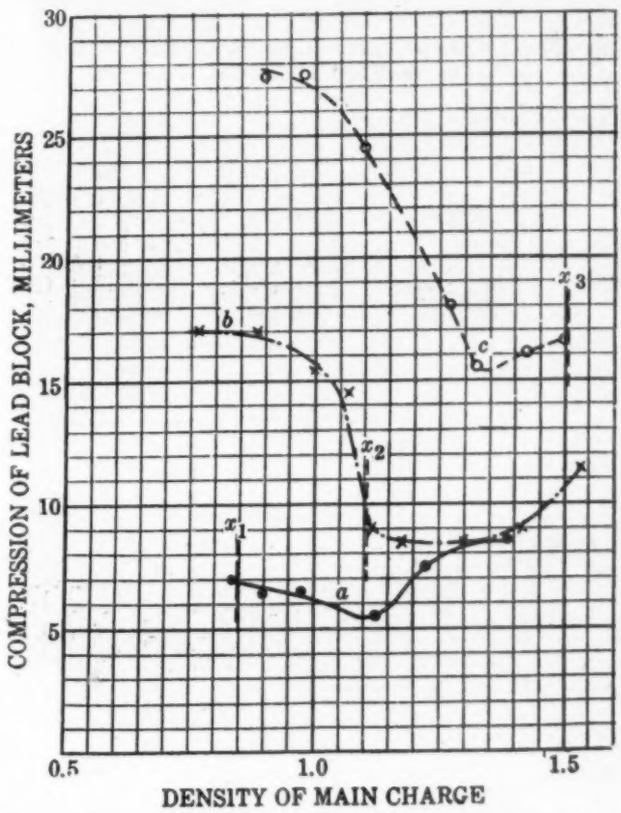


Fig. 4. Compression of Small Lead Blocks by 100 Grams of Ammonium Nitrate with 50 Grams of Amatol (80:20) as Booster, Variation of Ammonium Nitrate Densities, and Confinement of Charge.

of the two salts at equivalent densities, tests were made to show the compression of small lead blocks by 50 grams of amatol 80/20 as booster charge, with ammonium sulphate at various densities, the charge being enclosed in ⅛-inch tubing. A similar series of tests was made using table salt (NaCl).

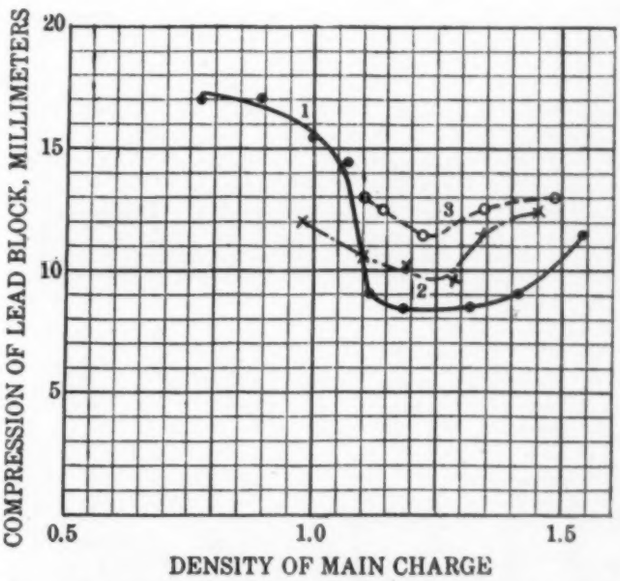


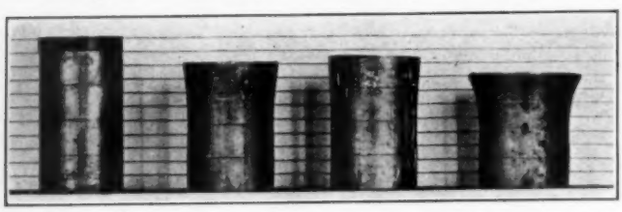
Fig. 5. Compression of Small Lead Blocks by 50 Grams of Amatol (80: 20) and (1) 100 Grams NH_4NO_3, (2) 100 Grams $(NH_4)_2SO_4$, (3) 100 Grams NaCl.

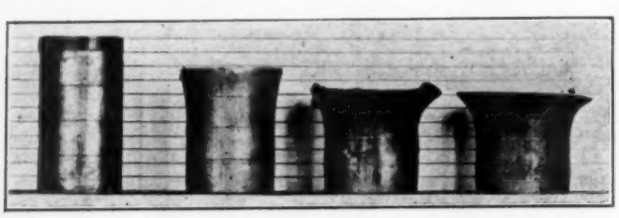
Plate I.

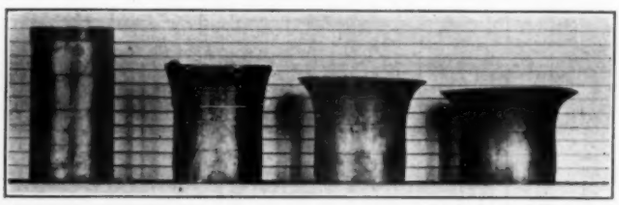
Compression of Small Lead Blocks With Varying Confinement of Charge.

Confinement:

	1/16 inch wall Shelby tubing	⅛-inch wall Shelby tubing	¼-inch wall Shelby tubing
Charge: 25 grams of TNT as booster on 100 grams of ammonium nitrate. (Density 0.71)			
Block before shot	M-3066 SB-18	M-3066 SB-19	M-3066 SB-20
Charge: 25 grams of TNT as booster on 137 grams of ammonium sulphate. (Density 0.97)			
Block before shot	M-3066 SB-124	M-3066 SB-125	M-3066 SB-126
Charge: 50 grams of TNT as booster on 100 grams of ammonium nitrate. (Density 0.71)			
Block before shot	M-3066 SB-14	M-3066 SB-13	M-3066 SB-10
Charge: 50 grams of TNT as booster on 137 grams of ammonium sulphate. (Density 0.97)			
Block before shot	M-3066 SB-127	M-3066 SB-128	M-3066 SB-129
Charge: 100 grams of TNT as booster on 100 grams of ammonium nitrate. (Density 0.71)			
Block before shot	M-3066 SB-22	M-3066 SB-21	M-3066 SB-9
Charge: 100 grams of TNT as booster on 137 grams of ammonium sulphate. (Density 0.97)			
Block before shot	M-3066 SB-132	M-3066 SB-130	M-3066 SB-131







The results of these tests are shown graphically in Figure 5, curves 1, 2, and 3 representing ammonium nitrate, ammonium sulphate, and sodium chloride, respectively. The form of the curves obtained is rather surprising, as we again have the occurrence of minima, and at practically the same density for all three salts. We are not able at the present time to explain these results satisfactorily, but they may be of considerable value for a study of the transmission of explosion and compression waves, and we contemplate a research along this line in the future. Without any adequate explanation of the results obtained with these non-explosive salts, the curves are still of great value in an interpretation of the results with ammonium nitrate as given in Figures 3 and 4.

Interpretation of Results

Inspection of Figures 3 and 4 leads to the conclusion that the minima of the curves represented densities at which no explosion of the ammonium nitrate took place. That such interpretation is unsatisfactory is shown in that such minima occur with inert or non-explosive salts also. Other evidence must therefore be sought to decide as to the effect of density upon the sensitiveness of ammonium nitrate to detonation.

In Plate I are photographs of the small lead blocks obtained with charges of ammonium nitrate (density 0.71) with varying confinement and varying weights of TNT as obtained in tests for determining the influence of confinement upon the explosibility of ammonium nitrate. It will be noted that, with the ammonium nitrate charges there is a tendency towards a mushroom shape, or the top of the block is convex; while, with the ammonium sulphate charges the top of the block is either perfectly flat or concave. Examination of the blocks obtained with charges of ammonium sulphate and sodium chloride at various densities likewise shows this flat or concave formation of the tops of the block (Plate II). If, on the other hand, we examine the blocks obtained with charges of ammonium nitrate of various densities, the data for which

Plate II.

Effect of Variation in Density of Non-Explosive Salt Charges Upon the Compression of Small Lead Blocks by the Booster Charge.

(50 grams of amatol 80/20 as booster)
(⅛-inch wall Shelby tube confinement)
Variation in density of ammonium sulphate charge (d)

M-3066 SB-255 d=1.10	M-3066 SB-254 d=1.28	M-3066 SB-257 d=1.35	M-3066 SB-253 d=1.44

Variation in density of sodium chloride charge (d)

M-3066 SB-261 d=1.23	M-3066 SB-259 d=1.33	M-3066 SB-263 d=1.34	M-3066 SB-258 d=1.48

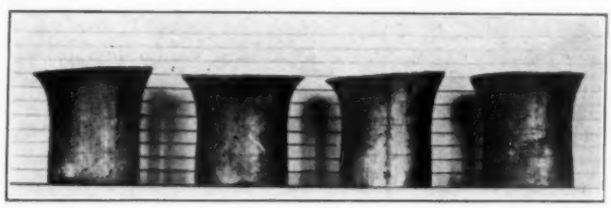
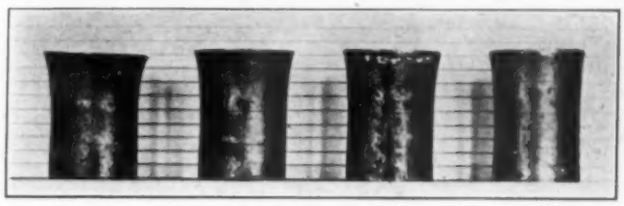


Plate III.

Effect of Variation in Density of Ammonium Nitrate Charges Upon the Compression of Small Lead Blocks.

(50 grams of amatol 80/20 as booster)
Confinement 1/16-inch wall Shelby tubing
Variation in density of ammonium nitrate (d)

M-3066 SB-230 d=0.84	M-3066 SB-231 d=0.90	M-3066 SB-226 d=0.97	M-3066 SB-227 d=1.12

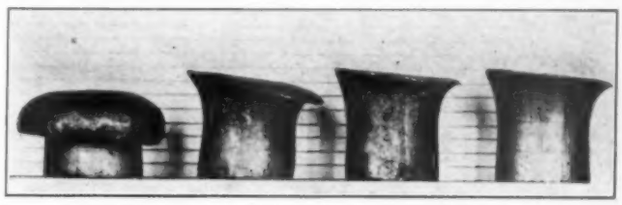


⅛-inch wall Shelby tubing

M-3066 SB-243 d=1.07	M-3066 SB-238 d=1.11	M-3066 SB-242 d=1.18	M-3066 SB-232 d=1.32

¼-inch wall Shelby tubing

M-3066 SB-249 d=1.10	M-3066 SB-247 d=1.27	M-3066 SB-246 d=1.32	M-3066 SB-244 d=1.42



were given in Figures 3 and 4, we find that the convex conformation of block top occurs up to a certain point, different for each series, and that, thereafter, with higher densities of charge, the flat or concave conformation occurs. It would seem, therefore, that explosion of the ammonium nitrate charge is indicated by convex block tops, and little or no explosion by flat or by concave block tops. Blocks from that portion of each series which show this transition from one type of block to the other have been selected, and are shown in Plates III and IV. From such evidence we have concluded that explosion of the entire 100-gram charge of ammonium nitrate does not take place above certain densities, varying with confinement and with nature of the booster charge. These conclusions are given in Table 2 and the densities are indicated in Figures 3 and 4 by X_1, X_2, and X_3.

TABLE 2.—Densities of ammonium nitrate above which complete detonation did not occur.

Confinement	Booster 50 grams TNA	Booster 50 grams amatol 80/20
1/16-inch wall Shelby tube	0.95	0.84
1/8-inch wall Shelby tube	1.31	1.11
1/4-inch wall Shelby tube	1.67	1.51

Even though complete detonation of the 100-gram ammonium nitrate charge does not take place at densities higher than those given in Table 2, nevertheless, it is probable that varying degrees of partial detonation take place throughout the entire series. The curves in Figures 3 and 4 represent, in all probability, the results of two simultaneous effects, and this fact may explain the differences in the form of the curves for different degrees of confinement. There is a pronounced break or discontinuity in the curves representing the transmission of the compression wave of booster charge through an inert salt (Fig. 5). It is probable that if it were possible to separate the compression effect of the ammonium nitrate charge from the compression effect of the booster, it would be found that complete detonation took place at all densities up to the values designated by X_1, X_2, and X_3 on the curves in Figures 3 and 4, and that, thereafter, partial detonation took place. The absence of sharp breaks at the minimum points for ⅛-inch wall confinement with amatol 80/20 booster (Curve b, Figure 4) is probably due to the fact that the minimum for transmission of the compression wave from the booster charge occurs at densities within the range of partial detonation, the extent of which is decreasing rapidly with density increase.

Effect of Pressure Upon Ammonium Nitrate Masses

There is considerable uncertainty, as evidenced in discussions in the N. R. C. Committee and in confidential reports of the British Ordnance Committee, as to the effect of pressures within ammonium nitrate masses upon its sensitiveness to explosion or detonation. It is possible that the data for the pressing of this salt to various densities may throw some light upon the question.

With large unconfined masses of ammonium nitrate, as in storage in large bins, re-crystallization or the weight of the salt itself may result in the development of considerable pressure within the mass of salt. Such pressure effects might influence the sensitiveness of the ammonium

Plate IV.

Effect of Variation in Density of Ammonium Nitrate Charges Upon the Compression of Small Lead Blocks.

(50 grams of TNA as booster)
Variation in density of ammonium nitrate (d)
Confinement 1/16-inch wall Shelby tubing

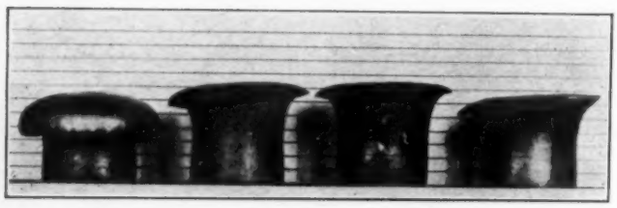
M-3066 SB-207 d=0.84	M-3066 SB-206 d=1.06	M-3066 SB-208 d=1.22	M-3066 SB-205 d=1.36

⅛-inch wall Shelby tubing

M-3066 SB-222 d=1.23	M-3066 SB-220 d=1.28	M-3066 SB-269 d=1.32	M-3066 SB-268 d=1.47

¼-inch wall Shelby tubing

M-3066 SB-215 d=1.21	M-3066 SB-216 d=1.36	M-3066 SB-214 d=1.52	M-3066 SB-217 4=1.68



nitrate in either of two directions. The additional confinement afforded by local highly compressed portions of the mass might render adjacent portions more susceptible to explosion or detonation; the greater apparent density of portions of the mass subject to such compression effects would tend to stop the propagation of the detonation. If one considers the relatively low pressures necessary for the attainment of densities (Figure 1) which interfere with the propagation of the detonation at different degrees of confinement (Figures 3 and 4), it would seem that, aside from any possible temperature effects, the development of local high-pressure areas within the ammonium nitrate masses would render such material less susceptible to explosion or detonation.

Efficacy of the Various Explosives as Boosters for Ammonium Nitrate

Results previously obtained[4] had indicated the following classification as showing the relative efficacy of the various explosives as boosters for ammonium nitrate:

High-content ammonium nitrate explosive > TNA > picric acid > tetryl > TNT > 60 per cent gelatin dynamite > 40 per cent ammonia dynamite > amatol 80/20; high-content ammonium nitrate explosive being the most efficient and amatol 80/20 being the least efficient.

The results with TNA and amatol 80/20 as boosters for ammonium nitrate charges of various densities bear out the above classification, as not only does TNA give greater compression values than amatol 80/20, a result which we might ascribe to the greater effect of the booster itself in compressing the lead block, but the TNA booster causes complete detonation at greater densities than does amatol 80/20 (Table 2).

In the grading of the various explosives according to their efficacy as boosters, explosives containing ammonium nitrate are placed at widely varying parts of the classification so that no generalization regarding them is possible. The greater efficacy of TNA over amatol 80/20 seems, however, to oppose the "synchronous vibration" theory of detonation.

Conclusions

1. The density of packing of the ammonium nitrate has a great effect upon its sensitiveness to detonation.
2. The effect of density increase in desensitizing ammonium nitrate varies with the confinement of the charge.
3. Aside from any possible temperature effects it seems probable that the occurrence of local highly pressed areas, in masses of ammonium nitrate under storage, would tend to render such masses less liable to detonation.
4. From the standpoint of their efficacy as boosters for ammonium nitrate, the various explosives may be graded as follows: High content ammonium nitrate explosive (nitroglycerin 9 per cent) > TNA > picric acid > tetryl > TNT > 60 per cent gelatin dynamite > 40 per cent ammonia dynamite > amatol 80/20; high content ammonium nitrate explosive being the most efficient and amatol 80/20 being the least efficient.
5. The influence effect, assumed in the "synchronous vibration" theory of detonation, is not apparent in the efficiency grading based on the experimental results.

[4]The Influence of Confinement Upon the Explosibility of Ammonium Nitrate, by J. L. Sherrick. ARMY ORDNANCE, Vol. IV, 1924, pp. 329-333.

Modern Precision Measuring Instruments

(Continued from page 384)

In testing a surface for flatness straight bands indicate a flat surface, and curved bands a curved surface. When comparing two gages for length, as shown in Fig. 8, they are of the same thickness, or length, if the bands on both gages match each other. A series of straight bands occurring between two flat surfaces indicates that there is a wedge of air between them. The bands run at right angles to the direction of the wedge. The shorter gage will have its point of contact with the flat lower down on the wedge than the longer gage, and the number of bands from the point of contact on the shorter gage to the point of contact on the longer gage indicates the number of units difference in length. When the bands are parallel, the surfaces are also.

The interferometer is an optical laboratory instrument of extreme precision. Measurements are obtained by means of interference of two beams of light. Optical mirrors are so arranged that waves of light pass between and through them. As these waves travel, they are divided and reflected a certain number of times. It is possible, with such an instrument to take measurements in units of a millionth of an inch.

Professional Notes

STANDARD TOLERANCES AND ALLOWANCES

The Committee on Plain Gages for Engineering Work believe that the terms and definitions used should, as nearly as possible, conform to those in common use. The coining of new terms should be avoided as far as possible, and, where a choice of terms is available, weight should be given the term being the most significant or subject to the least misconstruction. With these ideas in mind, the following fundamentals and definitions have been adopted.

Fundamentals

DIRECTION OF TOLERANCE ON GAGES

1. The extreme sizes for all plain limit gages shall never exceed the extreme limits of the part being produced. All variations in the gages, whatever their cause or purpose, shall bring these gages within these extreme limits. Thus a gage which represents a minimum limit may be larger but never smaller, than the minimum size specified for the part being produced; while the gage which represents a maximum limit may be smaller, but never larger, than the maximum size specified for the part being produced.

2. Temperature at which gages shall be standard. This Committee recommends the use of 68 deg. fahr. (20 deg. cent.).

3. The final result sought by gaging is interchangeable manufacture in some degree. This means that the parts of a mechanism can be assembled without *fitting* one part to another and when assembled the mechanism will function properly.

4. Applied to manufactured material, the result sought is sufficient uniformity in size and contour to adapt the material to the requirements of the industries without further fitting. The fundamental principle involved in interchangeable manufacture requires that "a system of standardization and classification of fits must establish a clearly defined line at which interference between mating parts begins." Hence,

(a) The standard or basic size, as physically represented by a correct standard master gage, represents the line at which this interference begins between mating parts.

(b) It is the minimum size of the external members of all mating parts of standardized practice, regardless of the kind of fit.

(c) It is the maximum size of internal members of all mating parts where interference begins or that fit metal to metal.

The condition of (b) and (c) is represented by a mating pair of correctly fitting standard gages.

(d) The limits of the component as physically represented by the limit master gages must never be exceeded as a result either of error or wear of the gages.

(e) "Go" gages or the equivalent verification of all the factors involved in the fit are necessary to prevent interference of mating parts.

In the case of force fits, "go" gages are necessary to determine the maximum amount of interference between mating parts.

(f) "Not go" gages or the equivalent verification of the determining factor is necessary to prevent the maximum looseness of mating parts exceeding the limits specified.

In the case of force fits, "not go" gages are necessary to determine the minimum amount of interference between mating parts.

Definitions

1. GAGING. A process of measuring manufactured material to assure the specified uniformity of size and contour required by the industries.

2. GAGE. A device for determining whether or not one or more of the dimensions of a manufactured part are within specified limits.

(a) RING GAGE. One with inside measuring surfaces circular in form. The measuring surfaces may be cylindrical or conical. The exterior shape or form of the gage is immaterial.

(b) PLUG GAGE. One with outside measuring surfaces arranged to verify the specified uniformity of holes. A plug gage may be straight or tapered and of any cross-sectional shape.

(c) RECEIVING GAGE. One with inside measuring surfaces arranged to verify the specified uniformity of size and contour of any piece of manufactured material.

(d) INDICATING GAGE. One that exhibits visually the variations in the uniformity of dimensions or contour, the amount of the variation being measured by a graduated scale or by marks, such as, dial, lever, flush-pin, plunger gages, etc.

(e) SNAP GAGE. A fixed caliper with inside measuring surfaces for measuring diameters, lengths, thicknesses, etc.

(f) CALIPER GAGE. One which for internal members is similar to a snap gage, and for external members is similar to a plug gage.

3. STANDARD. A fixed physical value defined by the Government, such as the yard and meter.

4. STANDARD SIZES. A series of subdivisions of the yard and meter having correct values.

5. NOMINAL SIZE. A name given to the subdivision of the unit of length having no specified limits of accuracy but indicating a close approximation to a standard size.

6. BASIC SIZE. The exact theoretical value from which all variations are made.

7. ALLOWANCE. An intentional difference in the dimensions of mating parts. It is the minimum clearance or the maximum interference which is intended between mating parts. It represents the condition of the tightest permissible fit or the largest internal member mated with the smallest external member. It is to provide for different classes of fit.

Example: A shaft dimensioned 0.874 in. and a hole dimensioned 0.875 in. represents an allowance of 0.001 in. Using the same hole with a shaft dimensioned 0.876 in. represents an allowance of 0.001 in. also; but, as the shaft is larger than the hole, this allowance becomes a negative quantity.

8. TOLERANCE. The amount of variation permitted in the size of a part.

Note: In the example under Allowance, the ideal condition has been given and the tightest fit permissible; but in manufacturing large numbers of pieces these sizes could not be produced exactly, so variations must be made that will not prevent their proper functioning but will enable them to be produced. These variations must therefore tend toward greater looseness. Therefore, if a manufacturing tolerance of 0.001 in. is required on each member, they would be dimensioned as follows:

Shaft	0.874 in.	+	0.000 in.
		−	0.001 in.
Hole	0.875 in.	+	0.001 in.
		−	0.000 in.

This defines a condition in which the greatest looseness is 0.003 in. and the greatest tightness is 0.001 in.

9. NEUTRAL ZONE. A positive allowance. (See "Allowance").

10. LIMITS. The extreme permissible dimensions of a part.

11. MASTER GAGE. One whose gaging dimensions represent as exactly as possible any physical dimension of the component. It is the gage to which all other gages and all dimensions of manufactured material are finally checked or compared, either by direct check or comparison.

(a) REFERENCE GAGE. A commonly used name for master gage.

(b) CHECK. Another commonly used name for master gage.

(c) STANDARD MASTER GAGE. Any master gage whose gaging dimensions have the standard or basic value of an

*Report of the Plain Gage Committee, organized under the rules of the American Engineering Standards Committee.

established nominal size. The legal authenticity of a standard master gage should be established by having its deviations ascertained by the Bureau of Standards at Washington.

(d) LIMIT MASTER GAGES. Gages which represent as nearly as possible the exact limiting physical dimensions of the manufactured material as established by the specified tolerances.

12. INSPECTION GAGES. Gages for the use of the manufacturer or purchaser in accepting the product. They must not accept any product which the master gages will reject.

13. WORKING GAGES. Gages used by the manufacturer to check the work as it is produced. They should not accept any product which the inspection gages will reject.

Classification of Fits

The following classification of fits is recommended:

LOOSE FIT (CLASS 1). This fit provides for considerable freedom and embraces those fits where accuracy is not essential.

Examples: Machined fits of agricultural and mining machinery; controlling apparatus for marine work; textile, rubber, candy, and bread machinery; general machinery of a similar grade; some ordnance material.

FREE FIT—LIBERAL ALLOWANCE (CLASS 2). For running fits with speeds 600 r.p.m. or over, and journal pressures of 600 lb. per sq. in. or over.

Examples: Dynamos, engines, many machine-tool parts, and some automotive parts.

MEDIUM FIT—MEDIUM ALLOWANCE (CLASS 3). For running fits under 600 r.p.m. and with journal pressure less than 600 lb. per sq. in.; also for sliding fits; and the more accurate machine-tool and automotive parts.

SNUG FITS—SMALL ALLOWANCE (CLASS 4). This is the closest fit which can be assembled by hand and necessitates work of considerable precision. It should be used where no perceptible shake is permissible and where moving parts are not intended to move freely under a load.

WRINGING FIT—NO ALLOWANCE (CLASS 5). This is also known as a "tunking fit" and it is practically metal-to-metal. Assembly is usually selective and not interchangeable.

TIGHT FIT—SLIGHT NEGATIVE ALLOWANCE (CLASS 6). Light pressure is required to assemble these fits and the parts are more or less permanently assembled. Such as the fixed ends of studs for gears, pulleys, rocker arms, etc. These fits are used for drive fits in thin sections or extremely long fits in other sections and also for shrink fits on very light sections. Used in automotive, ordnance, and general machine manufacturing.

MEDIUM FORCE FIT—NEGATIVE ALLOWANCE (CLASS 7). Considerable pressure is required to assemble these fits and the parts are considered permanently assembled. These fits are used in fastening locomotive wheels, car wheels, armatures of dynamos and motors, and crank disks to their axles or shafts. They are also used for shrink fits or medium sections or long fits. These fits are the tightest which are recommended for cast iron holes or external members as they stress cast iron to its elastic limit.

HEAVY FORCE AND SHRINK FIT—CONSIDERABLE NEGATIVE ALLOWANCE (CLASS 8). These fits are used for steel holes where the metal can be stressed to its elastic limit. These fits cause too much stress for cast iron hole. Shrink fits are used where heavy force fits are impractical such as locomotive wheel tires, heavy crank discs of large engines, etc.

TABLE 1—LOOSE FIT (CLASS 1)

DIAMETER From	DIAMETER Up to and Incl.	Mean	LIMITS Hole +	LIMITS Hole —	LIMITS Shaft —	LIMITS Shaft —	Tightest Fit Allowance +*	Loosest Fit Allowance + Tolerances +*
0	3/16	1/8	0.001	0.000	0.001	0.002	0.001	0.003
3/16	5/16	1/4	0.002	0.000	0.001	0.003	0.001	0.005
5/16	7/16	3/8	0.002	0.000	0.001	0.003	0.001	0.005
7/16	9/16	1/2	0.002	0.000	0.002	0.004	0.002	0.006
9/16	11/16	5/8	0.002	0.000	0.002	0.004	0.002	0.006
11/16	13/16	3/4	0.002	0.000	0.002	0.004	0.002	0.006
13/16	15/16	7/8	0.002	0.000	0.002	0.004	0.002	0.006
15/16	1-1/16	1	0.003	0.000	0.003	0.006	0.003	0.009
1 1/16	1 3/16	1 1/8	0.003	0.000	0.003	0.006	0.003	0.009
1 3/16	1 3/8	1 1/4	0.003	0.000	0.003	0.006	0.003	0.009
1 3/8	1 5/8	1 1/2	0.003	0.000	0.003	0.006	0.003	0.009
1 5/8	1 7/8	1 3/4	0.003	0.000	0.004	0.007	0.004	0.010
1 7/8	2 1/8	2	0.003	0.000	0.004	0.007	0.004	0.010
2 1/8	2 3/8	2 1/4	0.003	0.000	0.004	0.007	0.004	0.010
2 3/8	2 3/4	2 1/2	0.003	0.000	0.005	0.008	0.005	0.011
2 3/4	3 1/4	3	0.004	0.000	0.005	0.009	0.005	0.013
3 1/4	3 3/4	3 1/2	0.004	0.000	0.006	0.010	0.006	0.014
3 3/4	4 1/4	4	0.004	0.000	0.006	0.010	0.006	0.014
4 1/4	4 3/4	4 1/2	0.004	0.000	0.007	0.011	0.007	0.015
4 3/4	5 1/2	5	0.004	0.000	0.007	0.011	0.007	0.015
5 1/2	6 1/2	6	0.005	0.000	0.008	0.013	0.008	0.018
6 1/2	7 1/2	7	0.005	0.000	0.009	0.014	0.009	0.019
7 1/2	8 1/2	8	0.005	0.000	0.010	0.015	0.010	0.020

* (+) denotes clearance or amount of looseness.
Note: All dimensions in inches.

TABLE 2—FREE FIT (CLASS 2)

DIAMETER From	DIAMETER Up to and Incl.	Mean	LIMITS Hole +	LIMITS Hole —	LIMITS Shaft —	LIMITS Shaft —	Tightest Fit Allowance +*	Loosest Fit Allowance + Tolerances +*
0	3/16	1/8	0.0007	0.0000	0.0004	0.0011	0.0004	0.0018
3/16	5/16	1/4	0.0008	0.0000	0.0006	0.0014	0.0006	0.0022
5/16	7/16	3/8	0.0009	0.0000	0.0007	0.0016	0.0007	0.0025
7/16	9/16	1/2	0.0010	0.0000	0.0009	0.0019	0.0009	0.0029
9/16	11/16	5/8	0.0011	0.0000	0.0010	0.0021	0.0010	0.0032
11/16	13/16	3/4	0.0012	0.0000	0.0012	0.0024	0.0012	0.0036
13/16	15/16	7/8	0.0012	0.0000	0.0013	0.0025	0.0013	0.0037
15/16	1-1/16	1	0.0013	0.0000	0.0014	0.0027	0.0014	0.0040
1 1/16	1 3/16	1 1/8	0.0014	0.0000	0.0015	0.0029	0.0015	0.0043
1 3/16	1 3/8	1 1/4	0.0014	0.0000	0.0016	0.0030	0.0016	0.0044
1 3/8	1 5/8	1 1/2	0.0015	0.0000	0.0018	0.0033	0.0018	0.0048
1 5/8	1 7/8	1 3/4	0.0016	0.0000	0.0020	0.0036	0.0020	0.0052
1 7/8	2 1/8	2	0.0016	0.0000	0.0022	0.0038	0.0022	0.0054
2 1/8	2 3/8	2 1/4	0.0017	0.0000	0.0024	0.0041	0.0024	0.0058
2 3/8	2 3/4	2 1/2	0.0018	0.0000	0.0026	0.0044	0.0026	0.0062
2 3/4	3 1/4	3	0.0019	0.0000	0.0029	0.0048	0.0029	0.0067
3 1/4	3 3/4	3 1/2	0.0020	0.0000	0.0032	0.0052	0.0032	0.0072
3 3/4	4 1/4	4	0.0021	0.0000	0.0035	0.0056	0.0035	0.0077
4 1/4	4 3/4	4 1/2	0.0021	0.0000	0.0038	0.0059	0.0038	0.0080
4 3/4	5 1/2	5	0.0022	0.0000	0.0041	0.0063	0.0041	0.0085
5 1/2	6 1/2	6	0.0024	0.0000	0.0046	0.0070	0.0046	0.0094
6 1/2	7 1/2	7	0.0025	0.0000	0.0051	0.0076	0.0051	0.0101
7 1/2	8 1/2	8	0.0026	0.0000	0.0056	0.0082	0.0056	0.0108

* (+) denotes clearance or amount of looseness.
Note: All dimensions in inches.

TABLE 3—MEDIUM FIT (CLASS 3)

DIAMETER From	DIAMETER Up to and Incl.	Mean	LIMITS Hole +	LIMITS Hole —	LIMITS Shaft —	LIMITS Shaft —	Tightest Fit Allowance +*	Loosest Fit Allowance + Tolerances +*
0	3/16	1/8	0.0004	0.0000	0.0002	0.0008	0.0002	0.0010
3/16	5/16	1/4	0.0005	0.0000	0.0004	0.0009	0.0004	0.0014
5/16	7/16	3/8	0.0006	0.0000	0.0005	0.0011	0.0005	0.0017
7/16	9/16	1/2	0.0006	0.0000	0.0006	0.0012	0.0006	0.0018
9/16	11/16	5/8	0.0007	0.0000	0.0007	0.0014	0.0007	0.0021
11/16	13/16	3/4	0.0007	0.0000	0.0007	0.0014	0.0007	0.0021
13/16	15/16	7/8	0.0008	0.0000	0.0008	0.0016	0.0008	0.0024
15/16	1-1/16	1	0.0008	0.0000	0.0009	0.0017	0.0009	0.0025
1 1/16	1 3/16	1 1/8	0.0008	0.0000	0.0010	0.0018	0.0010	0.0026
1 3/16	1 3/8	1 1/4	0.0009	0.0000	0.0010	0.0019	0.0010	0.0028
1 3/8	1 5/8	1 1/2	0.0009	0.0000	0.0012	0.0021	0.0012	0.0030
1 5/8	1 7/8	1 3/4	0.0010	0.0000	0.0013	0.0023	0.0013	0.0033
1 7/8	2 1/8	2	0.0010	0.0000	0.0014	0.0024	0.0014	0.0034
2 1/8	2 3/8	2 1/4	0.0010	0.0000	0.0015	0.0025	0.0015	0.0035
2 3/8	2 3/4	2 1/2	0.0011	0.0000	0.0017	0.0028	0.0017	0.0039
2 3/4	3 1/4	3	0.0012	0.0000	0.0019	0.0031	0.0019	0.0043
3 1/4	3 3/4	3 1/2	0.0012	0.0000	0.0021	0.0033	0.0021	0.0045
3 3/4	4 1/4	4	0.0013	0.0000	0.0023	0.0036	0.0023	0.0049
4 1/4	4 3/4	4 1/2	0.0013	0.0000	0.0025	0.0038	0.0025	0.0051
4 3/4	5 1/2	5	0.0014	0.0000	0.0026	0.0040	0.0026	0.0054
5 1/2	6 1/2	6	0.0015	0.0000	0.0030	0.0045	0.0030	0.0060
6 1/2	7 1/2	7	0.0015	0.0000	0.0033	0.0048	0.0033	0.0063
7 1/2	8 1/2	8	0.0016	0.0000	0.0036	0.0052	0.0036	0.0068

* (+) denotes clearance or amount of looseness.
Note: All dimensions in inches.

Explanatory Notes

In the table reproduced below many of the terms in common use in the shops of the country are given with the equivalent term which this Committee's report recommends:

Greatest Tightness Least Loosneness Tightest Fit Neutral Zone Maximum Metal	Are all common terms which are the same as—	ALLOWANCE
Least Tightness Greatest Looseness Loosest Fit Minimum Metal	Are all common terms which are the same as—	ALLOWANCE PLUS TOLERANCES
Difference between largest and smallest permissible size of either members. Variation in the size allowed	Now called—	TOLERANCE

The basis for the preceding recommended allowances and tolerances is classification of fits, quite commonly known to the manufacturing public. Interference between mating parts takes place at the exact basic value of the dimension; hence an accepted pair of mating standard gages become the "go" gages for mating parts which will prevent interference at the basic value of the dimension.

On account of the lack of a uniform and acceptable method of measuring the fitting surfaces of external members of a pair of mating parts, it is recommended that plugs, blocks, discs, and rods govern the checking of external members for the reason that usually the same measuring device will check for accuracy both the internal member and the gage for the external member, thus avoiding an interference when both members appear to have the same dimension.

To illustrate: If a 2-in. hole be measured with an inside micrometer and a shaft be measured with an outside micrometer, and both measure exactly 2 in., there is no assurance they will go together; but, unless there was a definite understanding in a contract, the pieces might be ruled acceptable by law. If, however, the 2-in. hole would receive a plug gage which measured exactly 2 in. by a measuring machine, it would also receive an accurately finished shaft of the same size when measured by the same machine.

It is well known that a correct pair of plug and ring gages 2 in. in diameter will each check parts that will go together. It is also well known that the character of fit depends on the rotundity, parallelism, size, and in some cases, contour of the mating parts, and that for cylindrical fits in mating parts, plug and ring gages are the only sure means of determining whether or not parts will go together. If either member of a pair of mating parts is three or five-cornered, a snap gage or micrometer will not insure their going together.

In the preceding allowances and tolerances, the best practice available was considered, and where differences occurred a compromise was attempted. The tolerance on holes apply only to reamed holes, or holes having a finish equivalent to reaming. From the standpoint of satisfactory performance, the tightest and loosest fits permissible are the all-important considerations. From a manufacturing standpoint, tolerances are the important factors. Hence both the tightest and loosest fit permissible must combine the tolerance and allowance, and therefore both allowance and tolerance must be considered for the all-around satisfactory conditions.

It is not deemed feasible at the present writing to lay down allowances and tolerances which will apply to all work. Many so-called standard fits are made in the industries which are not interchangeable, and an attempt to make them so would be prohibitive in cost. They do, however, require to be made on a production basis, and it is believed that the tables here given will be found to contain allowances and tolerances which are suitable for most work, even if some selection or individual fitting of parts is desired.

In choosing the class of fit for manufacture, the engineer should keep in mind that cost usually increases proportionately to the accuracy required, and no finer class of fit should be chosen than the functional requirements actually demand. It is axiomatic that the closer the fit the smaller the manufacturing tolerance, and usually the greater the cost. The length of engagement of the fit also plays an important part in the selection of the class of fit for a piece of work. It is obvious that a long engagement will tolerate more looseness than a short one, and due regard should be paid to this feature.

Ed. Note: Copies of the complete report may be obtained from the Committee, Care Bureau of Standards, Washington.

ARTILLERY DIVISION

Winkley "Odograph."—The Winkley "Odograph," an instrument for the blind steering of tanks, has been delivered to the Aberdeen Proving Ground by the manufacturer. A series of tests with this instrument will be started soon in an effort to determine the value of this instrument for tank steering by chart rather than by direct observation.

Test of Best S-30 Tractor.—The Best S-30 Tractor has completed its Ordnance Department test. Approval of its release for service test was given with the provision that an effort be made to increase its speed in so far as this can be done safely by increasing the engine speed. The tractor will be overhauled and shipped to Fort Bragg, together with the necessary spare parts for a service test of one year's duration.

Corps Tractor, Model 1921 E.—The Corps Tractor, Model 1921 E, has been completed, has received its shop test, and been shipped to the Proving Ground for test. In reporting the status of this vehicle, the C. O., Rock Island, suggested changes looking to the elimination of the overhang at the front end, complications in the control mechanism due to the forward location of the driver, the convertible feature and the cargo-carrying feature. While it is realized that carrying out these suggestions would probably result in a more satisfactory drawbar vehicle, it is the opinion of the Ordnance Committee that since the vehicle is completed it should be tested in its present condition, and that after tests are completed the question of modification should be considered. A test program for the test of the Corps Tractor, Model 1921, was prepared, approved, and forwarded to Aberdeen Proving Ground for action. The features of this program cover the usual tests of vehicles of this class as a drawbar vehicle, and include an additional test covering the cargo-carrying feature. The cargo load for this particular vehicle is limited to two tons.

Tests of Balloon Tires.—As a result of a series of tests at Aberdeen with a stripped Ford car equipped with balloon tires of different sizes, decision has been reached to continue these tests with a more substantial chassis. The tests of a four wheel vehicle equipped with balloon tires will be continued using a Dodge chassis. The type of transmission used in this car will make it better suited for this test than the Ford chassis. The unit pressure per wheel will be higher than with the Ford chassis, but the tests should show whether the increased durability and longer life will offset some of the disadvantages of the heavier car.

Duda Photographic Chronograph.—The Franz Duda photographic chronograph, purchased in Austria, has been shipped to Aberdeen Proving Ground for test. This is a portable photographic chonograph, which can be used for measuring muzzle velocities at any angle of elevation of the gun without the use of towers or screens.

Design of Power Chart.—The Design Section at Rock Island Arsenal has submitted a set of study drawings for a power cart weighing about 750 lbs. and capable of a maximum speed of 3¼ miles per hour. The body of the cart has been arranged to transport infantry accompanying gun carriages mounted on their wheels. For ordinary operation, the cart is arranged for four wheel drive, with or without chains over the tires; for very difficult ground a flexible type of track may be placed over the wheels. The design provides for steering by a controlled spur gear differnetial in the axles by which the outside wheels are driven approximately at twice the speed of the inside wheels; steering is also assisted by the manual effort of the operator on the handle bar.

BUREAU OF STANDARDS

Machine Gun Barrel Steels

The investigation which has been in progress at the Bureau of Standards for several years on the suitability of machine gun barrels made of special steels is now drawing to a close. The principal purpose of the investigation was to find a steel for this purpose superior to the type now used, thereby increasing the accuracy and life of the gun.

At present, data are being tabulated on the correlation of composition and the effects produced upon the surface of the bore during firing and the accuracy, wear and velocity of the gun. No final conclusions can as yet be drawn. It is believed, however, that the results of the investigation which is one of the most extensive of this kind yet under-

taken, or at least yet published, will throw a good deal of light on the nature and distribution of the erosion which occurs in the barrels during service as well as the relative value of a considerable number of steels most of which were suggested by ordnance metallurgists as being possibly suitable for use in the manufacture of machine gun barrels.

PICATINNY ARSENAL

Lightning Protection for Powder Magazines

The indifference with which we accept loss and hazard due to preventable causes is well illustrated in industries using explosives. Magazine areas which are being struck by lightning repeatedly with great loss in life and property continue unprotected. While there is much to be learned regarding the behavior and control of lightning, and while the best known design and installation may not be an absolute guarantee against loss by lightning there is every reason to believe that a system installed in accordance with modern methods affords an almost absolute measure of protection.

It is generally recognized that certain areas are more susceptible to being struck by lightning than others. In such areas very complete systems of protection are required. On the other hand, the ordinary buildings in closely built sections, such as cities and towns, are seldom struck. In such sections little protection, if any, is required. To this latter there are exceptions such as chimneys, towers, and buildings with elevated features, such as spires and cupolas.

Protection against lightning is advisable for isolated buildings and buildings having elevated features such as towers or chimneys. In theory, the proposed system of protection aims at reducing the difference in potential between the earth and the area over the building being protected, and at the same time providing a system of sufficient capacity to transmit a sudden discharge.

The essential parts of an installation are, air terminals, conductors, and grounds, or earth terminals. Installations are of two general types, the first in which the system is installed on the structure to be protected, the second where the system is independent of the building, and supported on an independent structure.

(a) The air terminals are the points of non-corrosive material elevated as high as is practical above a building, structure, chimney, or area to be protected. Cupolas, ventilators, and other elevated features of buildings should have air terminals whenever a system of protection is installed on the building. These air terminals must be suitably braced.

(b) The conductors are cables, rods, or other electrical media connecting the air terminals with each other and with the grounds or earth terminals. If the system is installed on a building all conductors should be connected so that the charge from one air terminal may reach the earth through any of two or more conductors and grounds. The conductors are usually of iron or copper, or any combination of the two.

The essential considerations are, electrical conductivity. and longevity. When the system is installed on a building the conductors are securely fastened without insulators; these fasteners should be spaced not over 5 ft. apart. Bends in the conductors should be of long sweep and in no case with a radius of less than 8 inches.

Copper cables should have a sectional area of not less than 0.4 sq. in., steel or iron cables not less than 1 sq. in.

Metal roofs and wall coverings, metal ceilings, steel towers, sash, and machinery should be connected to the conductors by good electrical contact.

Connections to conductors should be positive; soldered connections are not acceptable. Preference should be given to splices and wrapped joints where cables are used, and to screw joints where rods are used. However, iron rods with eyebolt connections, such as have done service for two centuries on church spires in the Eastern States are not credited with failure due to type of splices.

(c) Grounds or ground terminals are the earth connection. For this purpose water mains are extensively used, although accidents have been reported due to this method of grounding. A copper plate surrounded by charcoal buried beyond the water level of the sub-soil (not less than 8 feet below grade) makes an acceptable ground. For this purpose the copper plate should be approximately 2 feet x 2 feet x ⅛-inch, and surrounded by not less than one bushel of charcoal. Ground connections require protection where they enter the ground as deterioration is most active at this point, and is not readily detectable. An examination of a comparatively large number of systems which failed to operate satisfactorily showed this to be by far the most fruitful source of failure. Connections between the ground cable and the conductor should be designed so that they can be readily disconnected for the purpose of testing the ground terminal.

In explosives process buildings and magazines, the building system of protection is less desirable than an independent system. For this class of buildings a mast of wood or steel located at some distance from the building makes a suitable support for the air terminal. Where a steel mast is used no conductor is required, if the mast is made an integral part of the system; positive connections between the air terminal and the mast and the mast and the ground terminal are required. To be satisfactory such a system requires a separate base for the mast with provision for holding the foot of the mast while it is being raised or lowered.

This system of protection in which tall masts are used has been found entirely successful for magazines and explosives manufacturing area in cases where the building system of protection failed to give the desired protection.

The area protected by an air terminal of a given height is not definitely known. An old rule to the effect that an air terminal protects anything within an imaginary cone of which the air terminal is the apex and the diameter of the base equals the altitude of the cone is subject to exception.

The list of inspected electrical appliances published semi-annually by the Underwriters' Laboratories contains a list of manufacturers of Materials for Lightning Rod Equipment whose standard products are regularly inspected at the factories and labeled under the Laboratories' Service.

Bromate-Free Potassium Chlorate.—Picatinny Arsenal has completed the manufacture of a lot of approximately 3,000 pounds of bromate-free potassium chlorate for Frankford Arsenal. This chlorate is of the grade prescribed for use in primer compositions and is not manufactured by any commercial firms in this country at the present time.

Grade A-4 Black Powder for Smoke Bomb Use.—As a result of experiments carried out at Picatinny Arsenal, it was determined that Grade A-4 Black Powder is satisfactory for use in Smoke Bomb Outfits. The service has, therefore, been authorized to use this grade of powder in place of the Army Black Saluting Powder, which was prescribed for use heretofore.

New 155-mm. Howitzer Ammunition for Service Test.—Preparations are being made to send to Fort Bragg and Fort Sill for service test a quantity of 155-mm. howitzer ammunition with latest developments in FNH powder, and with the new combination superquick and short delay fuzes. Similarly, a quantity of 75-mm. ammunition with FNH powder and latest developments in fuzes is being sent out for service test.

Tests of 155-mm. Star Shell.—Tests have been conducted with experimental 155-mm. star shell (illuminating projectile). In the firing of ten rounds the action was fairly satisfactory, there being one failure of a parachute to open and one partial failure.

Ammunition for Development Tests 37-mm. Colt Automatic Gun.—One hundred and sixty 37-mm. rounds with 100 per cent charge for the 37-mm. Colt Automatic Gun were shipped from Picatinny Arsenal to the Colt's Patent Fire Arms Manufacturing Company for use in development tests of the gun in question.

Ammunition for Service Tests 37-mm. and 75-mm. Infantry Cannon.—Two hundred and fifty rounds of ammunition for the 37-mm. Infantry Gun Model 1923 E, 2,000 f.s. and 250 rounds for the 75-mm. Infantry Mortar are being assembled at Picatinny Arsenal for shipment to Fort Benning for service test of the 37-mm. Infantry Gun, Model 1923 E, and the 75-mm. Infantry Mortar, respectively.

ROCK ISLAND ARSENAL

Medium 1924 Tank

Brown-prints covering the details of a number of the units of the Medium 1924 Tank have just recently been sent to the Ordnance Office. These will be followed with additional prints as different units are completed and checked. The work of detailing the layouts received from the Ordnance Office is rapidly proceeding and is being given priority over all other work.

10-Ton Tractor

Drawings have been released covering a new type of pintle for the 10-ton Tractor. This pintle is now in process of

manufacture. The design of the pintle for the 5-ton tractor is complete, but this will be held until the 10-ton pintle is completed, in case that there might be some suggestions or changes that might present themselves after examining this design.

4.7-inch Gun Motor Carriage, Model 1922 E

The 4.7-inch Gun Motor Carriage, Model 1922 E, has been partially road tested, and after partial proof-firing it was decided that a change in the outriggers was necessary to give it proper stability. This change has, therefore, been designed and will be installed on the mount this week. It is expected, therefore, that the test will continue within a week. It was found in proof-firing that the horizontal component of the firing load was sufficient to cause too great a set-back of the vehicle as a whole. The redesign of outrigger provides for placing the float normal to the axis of the outrigger trail, as in the Motor Carriage for the 155-mm. Gun—8-inch howitzer.

Recoil Mechanism

Trouble has been experienced with the sticking of the replenisher pistons in the Filloux type of recoil mechanism. This sticking was due to the expansion of the rubber packing owing to absorption of oil. The Ordnance Office authorized the development of metallic packing to cure this defect, and as a result of tests to date it is believed that this problem has been solved.

Pneumatic equilibrators as now designed functioned well up to 45 degrees elevation, but when higher angles than 45 degrees were required the plotted load curve of the equilibrator gradually diverged from the plotted load curve of the tipping parts. This condition meant the use of a cam to vary the effective arm of the equilibrator, or the use of a double equilibrator such as designed for the 3-inch A.A. Gun Mount, M 1923, now under construction at this Arsenal. The double equilibrator for this mount has to handle a movement of 85 degrees, from 5 degrees depression to 80 degrees elevation. Both of the above methods in compensating for the diversions of the above-mentioned curves add complication and weight to construction. A much simpler method has been devised for overcoming the above-mentioned difficulty, which will permit the use of an equilibrator in its simplest form with only the addition of a few additional parts, for which there is room in the equilibrator itself.

75-mm. Pack Howitzer, M 1923 E

During recent test of the 75-mm. Pack Howitzer, M 1923 E, it was found that, owing to the overhang of the tipping parts from their supports, the deflection of the parts was sufficient to bind the recoiling parts in the ways of the cradle. In shop test it was found that this binding was of such magnitude as to prevent the piece returning to battery position when it was retracted. In proof-firing it was found that this binding was not great enough to prevent the piece from returning into battery but was sufficient, it is believed, to slow up the movement of the recoiling parts at the end of counter-recoil. The ways of this piece have a smaller vertical clearance than is customary, and investigation is now being made into the desirability of allowing a greater vertical clearance between the cradle ways and the slides.

155-mm. Howitzer Carriage, M 1925

Good progress is being made in the design of the 155-mm. Howitzer Carriage, M 1925, at Rock Island Arsenal. Studies to date indicate that this carriage can be made very similar to its sister piece—the 4.7-inch Gun Carriage, M 1921 E—the greatest differences in the general plan being the location of the traversing arc in front of the top carriage and the moving of the trunnions to the rear, both of these differences being necessitated by the 65-degree elevation of the howitzer. As the power of the howitzer is greater than that of the gun, it will, of course, be necessary to use heavier parts. The general appearance of the new howitzer carriage should very closely resemble the appearance of the 4.7-inch gun carriage, M 1921. The cradles of the two carriages will be very similar, but, of course, it will be necessary to change the mechanism within the cradle to accommodate the increased power and size of the howitzer.

THE THOMPSON GUN

Thieves, after committing a holdup or a robbery, are able to flee in motor cars because a policeman armed with only a regulation pistol, while pursuing the bandits, finds it difficult to shoot straight and "wing" the outlaws. This condition has caused the police departments of several of our large cities to adopt the submachine gun invented by General John T. Thompson, who was director of arsenals and chief of small arms production during the world war.

In order to show the effectiveness of this gun during a bandit chase a demonstration was recently carried out at Tenafly, N. J. The weapon was mounted in a side-car of a motorcycle and operated by a policeman. The motorcycle pursued a seven-passenger motor car supposed to contain thugs attempting to make a getaway. The auto was towed by another car a safe distance ahead. These two were running at a fast clip and the motorcycle was about 50 yards to the rear. The submachine gun operator opened fire on the "bandits' car" and a hail of .45 calibre bullets punctured its tires full of holes, bringing the machine to a halt. It would have been an easy matter for the officer to hit any one sitting in the automobile and if the crooks, armed with the best automatic pistols, had tried to shoot the pursuing officer they would have found it extremely difficult to "get" him at a distance of 50 yards. The odds were heavily against them from the moment the anti-bandit gun opened fire.

A demonstration was also made to show what the gun can really do to an automobile when this becomes the target of automatic firing. At a distance of about 30 feet three of these guns blazed away simultaneously at the touring car just referred to and while it remained stationary. Counting the combined fire of the three weapons, bullets poured into the car at the rate of over 2,000 per minute. And this fire reduced the machine to a pile of junk in less than a minute's time. The tonneau was perforated till it looked like a Swiss cheese; the radiator was ripped to pieces, and the gas tank and the steering gear were utterly wrecked. Finally an incendiary bullet was shot in the spilled gasoline and instantly the car was a mass of flames.

The anti-bandit gun has been made practical and safe within densely populated districts by the introduction of birdshot cartridges. The latter, in conjunction with the marked accuracy of the weapon, insure the safety of innocent bystanders beyond the range of a few feet. The birdshot cartridges will inflict severe punishment on a crook without fatally wounding him.

The gun weighs only 9½ pounds and is, therefore, the lightest rapid-fire gun in existence. The next lightest automatic gun weighs 18 pounds. The weapon can easily be held in one hand and fired accurately. (*Scientific American, April, 1924.*)

MR. BARUCH ON MOBILIZATION

Mr. Bernard M. Baruch, Chairman of the War Industries Board during the World War, made the following address before the Purchase, Storage and Traffic Division at a dinner held on April 7, 1924, in New York:

"I recommend that legislation be put into effect that would give power to the President, in case of war or threatened war, to mobilize immediately the resources of the nation. That would mean the mobilization of men, money, materials, manufacturing facilities, and food; the fixing of all prices—that means labor also; and the regulation and distribution of production. In charge of this work an industrial strategist or board should be placed. I am opposed, however, to boards, except where final authority rests with the chairman, as divided authority causes indecision, and indecision means defeat in war. The purpose of such a board as I have in mind would be to furnish the fighting forces with what they need when they need it, with the least dislocation of the civilian processes.

"The mobilization of man power would mean not alone the fighting forces, but the total man power. For instance, there would be mobilization of engineers, chemical, mechanical or metallurgical; of doctors, and of the trained minds in their various fields of endeavor. The military authorities should put into effect a draft of the entire population, from which the required number of men should be drawn; the military authorities should place the necessary orders for equipment and materiel, and inspect and receive them. The industrial strategist would say from what industries the men should be taken, giving the Army and the draft boards a list of the essential and less essential industries, and he would indicate what proportion of its peace-time quota each industry should be permitted to produce. With these facts in front of them, the draft boards could act intelligently.

"All industries would be organized, as during the last war, in small compact committees. Over each industry would be a director. With the director would be associated a representative of each supply department that required the use of the particular material or the services of that particular industry. So with the director would sit representatives of all the demand, whereas a committee of the industry would represent all the available supply and substitutes therefor.

"Prices of materials, commodities, and, in fact, all things, would be declared fixed as of such and such a date, and it would be illegal either to buy or sell at a different price. A price-fixing committee would be immediately inaugurated for the purpose of making such changes in prices as became necessary.

"Money would be mobilized the same as men and materials and allocated for the purpose of winning the war. Labor, in its broader sense, meaning all those who perform services, professional, banking, commercial or otherwise, would be allocated under the plan.

"The principal direction of labor would come through the stimulation of some industries, increasing the demand for labor and services therein, but also through lessening the activities in less essential industries by curtailing their output. The movement of labor and services would not be directed by the military, but by the industrial strategist in thus increasing and lessening the demand for labor and services, but still leaving, as in peace time, the selection of employment more or less to the choice of the man performing the services.

"Power, fuel, and the railroads, through priority, would be under the control of the industrial strategist, who, when the various needs were placed before him, would declare by the system of priority where men and materials should be used. He would further say where they should not be used. There would be stimulation of production by putting more men, more money, and more transportation into the production of essentials, and a cutting off of demands by denying the use of men, money, materials, and transportation to industries not engaged in war work. Priority was the War Industries Board's most effective instrument because on it depended the allocation of our resources on the basis of their use towards the quickest winning of the war. So it would be in this present organization. During the war the final priority was vested in the chairman of the War Industries Board, but at his right hand always sat the military authority, whose needs were the final and determining factor.

"This briefly outlined organization is nothing new. It was really being done at the close of the war. I am recommending it because I think we ought to start at least where we ended and not again go through the unnecessary confusion and grief of the last war.

SMOKE SHELLS

Characteristics of Smoke Shell.—Smoke shell are filled with either white phosphorous (W P) or titanium tetrachloride (F M). These two kinds of shell are used, respectively, for forming smoke screens and for the adjustment of gas shell fire. Either can be used for either purpose, but the W P shell is much superior for forming smoke screens and the F M shell for ranging; in fact, the F M shell is only about 40 per cent as efficient as the W P shell for screening purposes. When using F M shell for ranging, preceding a gas shoot, the necessary corrections must be made for the difference between shells when passing to fire for effect.

Use of Smoke Shells.—Smoke shell is used to form a smoke screen to blind the enemy. These screens may be used against observation posts, machine gun emplacements or even against the troops themselves. Smoke shells are also used to define the limits of an attack or raid, to draw fire and to divert attention from some other operation, or to stimulate gas attacks. Its use came more and more into favor during the World War. It was used, on occasion, in the near edge of our own rolling barrage to mark it clearly for our own troops, and to screen our troops from the observation of the enemy. Such use is apparently somewhat debatable. It reduces the number of guns firing shell and shrapnel and some claim that it furnished the enemy a definite point to aim on. The British artillery often put down smoke in a barrage just before it began to move forward in order to mark the line of the barrage and as a signal to the infantry that the movement of the barrage had begun. Smoke shell cannot be depended upon for much screening effect when fired in wind of much over twenty miles per hour. The amounts of smoke shell required to fire screens under various conditions are given in detail in your Artillery Notes. The figures there given were taken from the latest data obtainable from the Chemical Warfare Service and are believed to be as nearly correct as any available today.

A study of these figures will show you that it is only under fairly favorable conditions that one can hope to effect much screening. On the other hand, favorable conditions, dull light, damp atmosphere, small wind, and so forth, are liable to be met with very frequently. The remarks concerning fuzes for gas shell are equally applicable to smoke shell. Smoke shell are normally carried by all division types.

Technical and Tactical Employment of Special Shell.—As we have stated above, the technical employment of special shell will be controlled by orders from division, corps and army commanders and not by the orders of artillery commanders. The following discussion of the tactics and use of special shell is taken from a paper by Lt. Col. M. E. Locke, F. A.:

"Destructive fire is intended to produce casualties. Lethal gasses are employed and as they are of low persistency the concentration must be quickly built up. This is secured for any given number of rounds by using as many guns as possible, firing simultaneously with a high rate of fire. The usual length of time is about two minutes, although under very favorable conditions, such as dead calm in thick woods or at night, fire may last for five minutes as a maximum.

"Neutralizing fire is intended to paralyze or greatly reduce human activity by wearing down morale and causing the mask to be worn for long periods of time. For this purpose recourse is generally had to persistent gasses, preferably to mustard. This concentration does not have to be quickly built up. Fewer guns and a slower fire are admissible.

"For counter battery work a burst of lethal gas is often given followed by a slow neutralizing fire with persistent gas. If this latter fire has been kept up for three or four hours, it is well to 'top off' with another burst of toxic gas after the mask's effectiveness has been reduced by a long period of use.

"Harassing fire is usually effected with tear gas, which makes long continual wearing of the mask obligatory to escape its annoying effects. Interdiction fire with gas in substance means simply to fill a hostile area so full of mustard that the enemy cannot stay there. An example of this was the town of Armentieres in the attack of March 21, 1918, by the Germans. There are also a great many strategems that can be practiced. Among them may be mentioned the mixing of lethal gas with a blinding smoke cloud, mixing gas with high explosive, the firing of a nauseating or coughing gas, causing the removal of the mask and following it with a burst of lethal gas, firing gas at night where men may be resting with masks off and possibly not near at hand, the mixing of a small amount of gas in our own rolling barrage, not enough to do real harm but enough to scare the enemy into putting on his mask. About one gun per battery (25 per cent) can be so used. With a four-mile per hour wind our troops can follow this barrage in one minute and without their masks. However, to sacrifice 25 per cent of the guns in barrage for this artifice is open to debate. This by no means exhausts the list of devices to fire gas with increased damage to the enemy. * * * * *

"In defense or in retreat the use of persistent gas is the rule, mustard preferred. The area vacated must be made untenable as possible for the enemy and for the maximum length of time. Mustard surpasses all other gasses for this purpose. This does not mean than gas is necessarily the best type of projectile to use. The effects of mustard are not immediately apparent and the hostile advance may be so rapid that casualties must be inflicted in the shortest space of time and in the greatest numbers. In such instances, we must come back to shrapnel and high explosive shell, if the enemy wear masks. In any stabilized condition, such as obtained during the first three years of the World War, persistent gas can be freely used."—(*The Coast Artillery Journal, March, 1924.*)

Reserve Corps Notes

A three-day course of training for Reserve Officers was held at the Ordnance Specialists' School, Raritan Arsenal, February 10, 11 and 12, 1924. About 25 officers were in attendance. A few of these officers started this voluntarily attendance at a course of instruction last year and this year each officer returned with several new recruits. A general course of instruction to cover duties of an Ordnance Officer with troops was pursued. The Reserve Officers in attendance were quartered at the Officers' Club. On February 12, 1924, they were guests of honor at a dance given by the officers and ladies of the post. Major L. D. Booth and Major T. J. Hayes from the office of the Chief of Ordnance were present and lectured to the officers.

Those who pursued the course included:

Lt. Col. F. C. Bull, Lt. Col. C. F. Judson, Lt. Col. H. B. Machen, Lt. Col. E. L. Sherwood, Major C. H. Hallock, Major L. W. Howard, Major W. D. Koch, Major C. G. Percival, Major H. B. Faber, Capt. A. B. Cox, Capt. S. Ireland, Capt. M. H. Behar, Capt. R. B. Cable, Capt. John Curtin, Capt. E. G. Blackford, Capt. J. B. Fidlar (Regular Army), Capt. O. S. Webb (on active duty as student officer O. S. S.), Capt. J. A. Helfert, Lt. D. H. Reed, Lt. L. L. Tremaine, Lt. Robert Fee, Lt. John Cetrule, Lt. J. B. Joyce, Lt. M. H. Clark, Jr., Lt. C. D. Van Sickle, Lt. H. W. Bender.

New Appointments

The following have been commissioned in the Ordnance Officers' Reserve Corps since the last issue of ARMY ORDNANCE.

Colonel Charles S. Mott. Lieut. Colonel George D. Babcock. Majors: Gustave E. Behr, Jr., James W. Mailler, Emmett H. Naylor. Captains: James F. Collins, Walter Arthur, John J. Klaber, Raymond B. Harris, Edmund S. Van Brunt, Stuart A. Wade. First Lieutenants: Edward O. Coates, Raymond E. Curly, Edward G. Curtis, Clifford I. Josephson, Edgar R. Lower, Kellogg D. McClelland, Edward N. Moor, Jr., Allen C. Morris, Frank E. Sullivan. Second Lieutenants: James Allen, Jules B. Aveilhe, Isidor Berkowitz, James W. Bracken, Ralph N. Campbell, Claude P. Cobb, Harold G. Evans, Ernest R. Hedstrom, John M. Keller, Williard W. Krauss, Maurice C. Libert, Stuart P. MacDonald, Russell B. Reader, Rufus R. Rosell, Ernest R. Skiles, Alfred E. Smith, Robert R. Wyker, Harley S. Van Vleet.

Reserve Officers Who Have Accepted Reappointment

Majs. Robert R. Abbott, Joseph E. Baker, Alfred DeG. Blake, James M. Boyle, Frederic M. Butts, Joseph P. Carlin, Dwight I. Cooke, Crosby Field, Albert E. Gastrock, Artemas Holmes, John C. Minor, George E. Morrissey, Jacques C. Nordeman, Charles E. Sholes, Furman G. Spencer, Joseph A. Steinmetz, Capts. George F. Aitken, Algernon W. Beecher, Chas. C. Black, William H. Boyer, William T. Comer, Howard Corlies, James S. Cox, Ralph C. Coxhead, William B. Curtis, Clarence E. Davies, Charles Demonet, Martin S. Eby, Charles L. Eshleman, Alfred J. Fenner, Dozier Finley, Burke Finnerty, Harry C. Ford, Frederick Wm. Hackstaff, Harold C. Hart, Wiley J. Huddle, Carleton H. Jones, Charles G. Kaelin, George E. Kellogg, Otto L. Kowalke, James Laughlin, Abraham N. Levin, Donald G. Miller, Elwood W. Miller, Peter C. Olsen, George A. Post, Berkley K. Postlewaite, Pierre A. Proal, Leo Ranney, John C. Smith, Harold B. Snyder, George M. Sprowls, Harold G. Stevens, Howard Tilson, Calvin Wm. Verity, Robert N. Wagener, George O. Walton, Francesco B. Whittemore, William F. Whittington, Walter M. Wickham, William R. Winans, Erwin G. Wurster, Oscar H. Wurster, Charles N. Young, 1st Lts., Fred A. Annett, Benjamin H. Ball, Cecil McC. Billings, Holger H. Bing, James E. Cohagan, John H. Cole, Dewees N. Crawford, Clifford A. Frazer, Dana E. Hill, John C. Kelly, Carl O.

Ordnance Reserve Corps Officers who Attended the Course of Instruction at Ordnance Specialists' School, Raritan Arsenal, Feb. 10, 11 and 12, 1924

Kienbusch, William H. Lacey, Ernest B. Lloyd, Donald V. Lowe, James F. Lyon, Roy Maxey, Thomas A. Miller, William E. Milne, John Mitchell, William F. Otis, Jacin H. Reece, Spencer S. Shannon, Henry Shepherd, Harry L. Short, Victor J. Smith, Xanthus R. Smith, Edwin B. Snow, Edward F. Stewart, Arthur F. Thornton, Edwin F. Washburn, 2nd Lts. Raymond M. Allen, Frederick R. Andrews, Henry H. Axworthy, Henry Bender, William H. Bost, Walter F. Bosworth, Thomas E. Burke, Robert G. Chess, George E. Cleveland, Harry L. Conley, James W. Cottrell, Robert F. Crowley, Robert H. Davidson, Clifford Wm. L. Day, John C. Dempsey, George D. Dickey, John M. Donnelly, Daniel M. Dowd, Mason Ehrenfried, Marvin L. Frederick, James E. Gay, Jr., Wm. M. Glasgow, Harry L. Grant, Fred Hanss, Anthony W. Harmon, Oscar R. Haverly, Sam C. Henderson, Henry M. Hermann, John F. Howard, Gordon R. Joslyn, Lewis E. Keil, Joseph A. Kessler, Ray C. Kivley, Jacob Kurtz, Harry L. Lauby, Frank W. Koeffler, Hiram D. Long, Frank T. Madden, John Wm. H. Mencke, Frank Wm. Miller, Jr., Robert L. Murphy, Earl A. Neilson, James J. Nolan, John J. O'Day, Jr., Edward G. O'Rourke, Frederick W. Orr, Stanley B. Palmer, Forrest M. Pearce, Albert L. Rasey, William J. Reilly, Jacob H. Reinecker, Burdick N. Richardson, Charles R. Ridington, Harry E. Rowe, Arthur G. Rubovits, William F. Rudy, Mark N. Russell, Philip G. Russell, George F. Sage, Conrad E. Sandvold, James A. Schafer, Alvin F. Sersanous, Elmer McC. Simmons, Ernest D. Skinner, Caswell Wm. Smith, Robert M. Smull, George C. Stebbins, Richard A. Taft, William H. Thompson, Earl M. Valentine, James F. Vreeland, Truman L. Ward, John B. Weidman, Joseph O. White, Jr., J. H. Zebley, C. G. Zwerner.

Industrial Preparedness Plans Tested

(Continued from page 390)

Chas. A. Finley—(Wire), Captain Wm. N. Holmes—(Tel.), Captain Warner McLaughlin—(Wire), Captain Joseph D. Murray—(Tel.), Captain A. F. Van Buskirk, Captain Granville E. Webster, 2nd Lt. E. E. DeCastro, 2nd Lt. Maurice Good—(Tel.), 2nd Lt. Herbert Kranich—(Tel.), 2nd Lt. Jacob Kurtz—(Wire), 2nd Lt. D. H. Reed—(Wire), 2nd Lt. Henry Bender.

Artillery Division:—Major R. R. Harrison, Major Daniel Royse, Captain Herman P. Gould, Captain F. L. Lindemuth, Captain Geo. A. Post, Jr.—(letter), 2nd Lt. Colby W. Bryden, 2nd Lt. Taylor B. Grant, 2nd Lt. L. L. Tremaine.

Auditing Section:—Major Allen H. Clarke, Captain Jas. F. Collins—(Tel.), 1st Lt. Theron H. Brown, 1st Lt. Chas. H. Towns, 2nd Lt. Lachlann Mackenzie.

Coordination Section:—2nd Lt. Jas. W. Bracken.

Legal Section:—Major G. N. Hunting—(Tel.), 1st Lieut. Edward G. Curtis, 1st Lieut. Ed. W. Stitt, Jr.—(Tel.)

Technical Section:—Captain John J. Burling, Captain John Curtin—(Tel.), Captain J. J. Klaber, Captain F. E. Townsend, 2nd Lts. G. W. Bingham and A. R. Lytle.

Small Arms Division:—Major Alexander Dow—(Tel.), Major Anthony Fiala, Major Harold B. Johnson, Major Chas. E. McQuigg, Major J. J. O'Connell, Captain R. B. Cable, Jr., Captain Chas. B. Mellen, Captain W. Van Alstyne, 1st Lt. N. DeF. Douglass.

Tank, Tractor & Trailer Division:—Major Earle Gatchell—(Wire), Major Harold C. Strohm, Major S. S. Thorn, Captain Wm. R. Patterson, 1st Lt. John Cetrule, 1st Lt. Christopher Gaus—(Tel.), 1st Lt. G. H. S. McNair—(Tel.), 2nd Lt. Haywood P. Cavarly, Jr.—(Tel.), 2nd Lt. Jas. R. Hemeon, also 2nd Lt. F. W. Spalding of the Boston District.

Bombs

(Continued from page 394)

in doing considerable damage in London and Paris alone. They dropped over 800 bombs on London killing over 500 people and wounding about 1,500. In one raid on London damage to the extent of £1,500,000 was done. Seven hundred and forty-six bombs were dropped on Paris, killing 266 people and wounding 603.

A glance at the pattern of the points of impact of bombs dropped on London plotted on a map of Philadelphia will indicate what might have happened to one of our cities had the United States been within the bombing radius of Germany. As it was, in spite of the great distances separating the two countries, plans were on foot in Germany, at the close of the war, to bomb New York, and a Zeppelin for this purpose was under construction.

In considering the damage done to London and Paris it must be realized that no bomb larger than the 300-kilo (660 pounds) bomb was dropped, while bombs six times as large are now available for use against such targets. On Paris alone only five 300-kilo bombs were dropped, of which only two functioned. The remaining bombs did not weigh over 100 kilos (200 pounds).

The effect of bombing upon morale is something which can not be estimated, yet is very apt to play an important part in the production of internal dissension in a country hard pressed by any enemy. Official reports state that aside from the direct damage resulting from bombing, the concern of the populace was sufficient to cause great lessening of activities as the people by seeking shelter from actual or expected raids caused a decided decline in production. While in many instances people went their way apparently unconcerned during a bombing raid, even the most nonchalant were affected, say what they will, by the siren announcing the approach of a raid, the roar of the antiaircraft artillery, the weird hum and drone of the aircraft engines, the crash of the bombs and the clatter of fire engine and ambulance rushing to the damaged area.

The controversy over bombs versus battleships, which has been the subject of so much discussion and comment, unfortunately can not be settled in time of peace, but there is no doubt that bombs properly placed can greatly damage and sink naval craft. Since the ex-German naval vessels were sunk, certainly much more attention has been paid to bombs, and had a test been held in which a portion of a city was similarly attacked, the public in general would doubtless indicate a still more lively interest in them.

Bombs have reached a stage in development where they can be relied on to function and do decided damage. They have progressed from crude devices of single purpose to specialized devices of diversiled use and may now be grouped with other important weapons of warfare as a powerful adjunct to the military strength of a nation.

(The End.)

Book Reviews

The Administration and Politics of Tokyo. By Charles A. Beard, Former Director of the New York Bureau of Municipal Research. New York: The MacMillan Company. 9 chapters, 184 pages. Price, $2.50.

In an age of great specialization, it is not surprising that municipal government has been the subject of intensive study. The need for such research has arisen out of many examples of municipal misgovernment, corruption, and failure to consider the ordinary advance of civilization. America is unique in having the first of these research organizations in the New York Bureau of Municipal Research.

Viscount Goto, Mayor of Tokyo, who is said to know more about municipal happenings in New York than most mayors west of the Alleghenies, had heard of the New York Bureau and appreciated its value. Consequently, when the will of Mr. Z. Yasuda provided 3,500,000 yen to found a similar institute in Tokyo, Viscount Goto naturally turned to the United States for suggestion. The author who is a former director of the New York Bureau, was invited to visit Tokyo to cooperate with the city authorities in developing a municipal program for the city. The task presented to Mr. Beard was fourfold:

(1) To arouse interest in municipal affairs among the citizens and students of Japan;
(2) To summarize American experience in dealing with concrete municipal problems;
(3) To assist the new institute in organizing its work;
(4) To make a free and unreserved report of the problems confronting Tokyo.

It is therefore of interest to learn how Dr. Beard accomplished such a mission in a foreign land. His book is a clear record of his participation in the enterprise. It furnishes an interesting commentary on the influence of America abroad when one reads that the best of our municipal institutions are being adapted to the needs of the capital of a great Oriental nation.

While the report of Dr. Beard applies primarily to Tokyo, the principles discussed are equally applicable to any municipal government. The book thus also furnishes an excellent source for the student of municipal affairs or for the casual reader who desires to know more of the functioning of municipal government.

Our America, the Elements of Civics. By John A. Lapp, with an introduction by Charles Kettleborough. Indianapolis, Ind.: Bobbs-Merrill Company. 27 chapters, 399 pages, illustrated, indexed. Price, $1.25.

This work was first copyrighted in 1916 and since then has passed through several revisions in order that the changes continually occurring in our government may be taken into consideration in the preparation of the text.

The book has established for itself a plan in its field and needs no introduction to the public. It is a clear, concise statement of the way we govern ourselves beginning with a view of the works and needs of people and carrying this through logically to the development of our government and its laws and the operation of its laws. It is essentially a text book containing excellent bibliographies on each chapter as well as on the book as a whole. Numerous questions for investigations and debate are suggested.

A final appendix contains the Declaration of Independence, the Constitution of the United States and the articles in Amendment of the Constitution, including the recent articles XVIII and XIX on prohibition and suffrage.

ARMY ORDNANCE welcomes this new revision of an excellent treatise on civics and commends the author in his attempt to keep the book abreast with the times.

The Inquisition. By Hoffman Nickerson; with an introduction by Hilaire Belloc. New York: Houghton Mifflin Company. 285 pages. Price, $4.00.

From start to finish this book is a gem. An introduction by Belloc is enough to give any volume a flying start; indeed in many cases it would handicap the author by setting up an unattainable goal of thought and style. Happily Mr. Nickerson has the ability and the capacity to sound the epilogue and all the intermediary stages between it and the prologue in the same high quality.

It seems safe to say that the Inquisition is one of the most misunderstood of all the misunderstood phases of history. Few have ever taken the trouble to understand it, many do not want to understand it, and fully as many more do not care much about it one way or the other, despite its effect on historical development. Mr. Nickerson has taken the Albegensian Crusade and the inquisition in Languedoc as the theme for an historical treatise that has received the strong praise of Mr. Belloc, the foremost midaevalist of our time.

First he gives a well-wrought pen picture of the XII and XIII centuries with entertaining descriptions of Lange d'Oc and the Albigenses. His treatment of the crusade itself and his account of the Battle of Muret, in 1213, have already received unstinted praise from literary and military reviewers.

Certain it is that military tactics of those times—notwithstanding the crude catapult—are essentially those of today. While our knowledge of weapons and inventive genius concerning them have progressed by leaps and bounds the essence of battle has changed but little. Those who are prone to decry the accomplishments of the Middle Ages would do well to study Mr. Nickerson's account of the siege of Muret. Simon de Montfort deserves a higher niche in the hall of military strategists than is commonly accorded him.

This book is written in a most liberal and broad-minded way. The author, while serving as a member of the Legislature of the State of New York "endured Prohibition lobbyists and cast about for something which might serve as a historical precedent in the way of religio-political oppression on so vast a scale." In the epilogue he draws this analogy in a fashion that is at once convincing in its statement, irrefutable in its logic and compelling in its earnestness.

Those of us who do not take kindly to the whole business of prohibition as it was "put over" can welcome a leader into our ranks—a leader who has stated the case in a consummate manner. Protagonists of strict enforcement, if they are of the stuff that profits by experience, can see in this treatise pernicious consequences that follow the denial of liberty of thought and action. And history repeats itself.

An Outline of the British Labor Movement. By Paul Blanshard. New York: George H. Doran Co. 174 pages. Price, $1.50.

Many Americans have read with interest of the phenominal rise of the Labor Party in Great Britain and have wondered as to the basic cause of its growth. The author, an American trade-unionist, has endeavored to answer this question by outlining its platform and *modus operandi*. No attempt has been made to theorize. Each chapter is an essay on some phase of the labor movement, among the more interesting being "What the Labor Party Would Do;" "How the Workers are Organized;" "Labor and Law;" "Whitby Councils and Trade Unions;" and "Security for the Workers." The style is simple and convincing and the text free from irrevelant matter so often found in books of this nature.

Considerable emphasis is laid upon the essential difference between American and British Labor Unions. The reasons why British employers seldom, if ever, resort to "strike-breakers" and why the labor unions seldom riot are fully analyzed. Wage scales, old age pensions, educational opportunities, and cooperative stores are briefly discussed and compared to American standards. It is freely predicted that

America will follow in the footsteps of the British Labor Party!

An introduction to the book is contributed by the Rt. Hon. Arthur Henderson, the prominent Laborite. The book gives an excellent bird's eye view of the Labor Party in Great Britain up to the time Ramsay MacDonald took over the reigns of Government.

Purchasing Principles and Practices. By John C. Dinsmore. New York: Prentice-Hall, Inc. Price, $4.00.

The need for men skilled in the technique of procurement and purchase was never so vital as it is today. The rapid strides made by industry and the development of business by combination or otherwise gave birth to the consolidation of purchases and the purchasing agent became an important factor. It is a far cry from the shoemaker who made the shoes for his neighbors to the factory that supplies shoes to the millions. New and complex problems arose and had to be surmounted in the process of development, not the least of which was obtaining raw material involving the questions of price, quality, quantity, transportation, etc.

In this book the writer draws a picture of modern methods of purchase, reciting some of the problems that confront the buyer, pointing out also to seller and buyer the pitfalls of purchase. The various types of purchasing agents to be met are faithfully depicted in the chapter on "Typical Purchase Department." Here the author shows that he is aware of the short-comings of some purchasing agents as well as alive to the requirements of the profession.

The book abounds in hints on the purchase of various commodities and contains numerous forms in use by various concerns throughout the country. To those interested in the problems of procuring supplies, to those in whose minds the bitter experiences of the years 1920 and 1921 are still fresh when large stocks of material were carried on inventory and the prices paid had to be scaled down, this book will prove a valuable guide.

Yields of Bonds and Stocks. By Johnson, Stone, Cross and Kircher. New York: Prentice-Hall, Inc. Price, $8.00.

The determination of the exact yield of a bond is an extremely difficult problem which few investors can solve. Approximations are usually made but they are on a whole unsatisfactory and require considerable time and often will not suffice. The authors have noted this fact and compiled a book similar to a log table which furnishes the information in a ready and usable way. They are to be congratulated on the arrangement and elimination of superfluous information. The ranges in prices and maturities are well chosen. Each page repeats the last line and last column of the preceding page—a great convenience as all users of mathematical tables will agree. All figures are shown to three decimal places with the half thrown over and indicated making the tables accurate to the nearest 5 ten-thousandths of one per cent.

The bond tables are set up to give the yield at market prices quoted on the stock and bond exchanges. Since there is an increasing demand on the part of investors to know the current yield as well as the bond yield, a column giving this yield has been added for all prices.

A section is devoted to stock yields which is of convenience to investors as well as a special section on premium bonds. The book will appeal to the small investor as well as the large and is a valuable contribution to the field.

The American Constitution As It Protects Private Rights. By Frederick Jesup Stimson, LL.D. New York: Charles Scribner's Sons. 11 chapters, 239 pages. Price, $2.50.

We might call this a personal edition of the American Constitution. We might also call it a unique discussion of the Constitution. It is both, and more: it is a fascinating treatment of a subject old yet ever new.

Dr. Stimson, as was to be expected, has performed his work well. It is rather a Herculean task to write such a book on the Constitution. It is difficult enough—in proportion, of course—to review one. It seems that every generation can produce a certain number of commentaries on our own Magna Carta. And almost every generation during the past one hundred and twenty-five years has. The changing times and conditions have always made it possible for thinkers to find new treasures and commentators to find new applications of old principles in our first and highest law.

It seems safe to say that the past two decades have produced more "situations" that bring the Constitution into play than any other similar period in our history. The Constitution has become a by-word; we can scarcely make a turn that we are not confronted with its application or its non-application—of one of the recent amendments, in particular. Therefore, a personal edition at this time is well chosen.

Dr. Stimson knows how to write. At the very start he gives no quarter to the old Gladstonian maxim about the Constitution being "struck off," etc., with which we are all familiar but which we all delight in hearing dissected and rejected over and over again. Then, too, this book is *different*: it selects all the sections and clauses of the Constitution that affect individual rights, and holds the mirror up to nature. Dr. Stimson's book will fill a great need if only our citizens will get it into their heads that the Constitution should be studied. Take the Bill of Rights, for instance, if the average individual could only read what this book says on the subject, and the way it says it, surely no one—neither ruler or ruled—would make the serious blunders so often made in the name of good intention.

Therefore, read this book! A few random excerpts might whet the appetite. But, as American citizens, all of us should know *intimately* just what are our rights to liberty, to property, to freedom of speech, to freedom of religion, and to freedom of home. It is not enough to have a hazy idea. Respect and reverence come only from accurate knowledge and if we want those institutions that have thrived under the Constitution in the past to endure for all time, then we should read such books as this one by Dr. Stimson and know what's what.

Manual of Military Training. By Col. James A. Moss, U. S. Army, and Major John W. Lang, U. S. Army. Menasha, Wisconsin: George Banta Publishing Company. 2 volumes. Vol. I, 37 chapters; Vol. II, 24 chapters. Price, $2.50 per volume.

During the World War the military establishment was of course expanded enormously. The number of officers increased from less than ten thousand in the Regular Army and National Guard to two hundred thousand. The problem of providing the influx of new officers with sound fundamental training doctrines would have been next to impossible of solution if there had not been on the market at the time the well known "Moss Publications." These publications filled a pressing need and supplemented in an interesting fashion the War Department training programs for the quick development of trained manpower.

It is therefore with great interest that the latest "Moss Publication" is received. It is found to be a true basic training manual in two volumes covering the current War Department instructions for Reserve Officers' Training Corps Infantry units and for the various courses in the Citizens' Military Training Camps. In addition, the scope has been broadened to include all information necessary for a successful company commander, using as a basis the primary fighting tactical unit, the platoon. The doctrines and methods expounded are derived from the experience of the World War as interpreted and applied by the Infantry School. Without doubt, the company commander of infantry who masters and applies to his unit the principles found in this manual will be insured an effective fighting organization equal to the various tasks which infantrymen are now called upon to perform. Profuse illustrations and simple language also make the book equally valuable for use by the enlisted men and the layman.

The work is in two volumes. The first volume is more or less elementary and aims at covering adequately the basic course at Reserve Officers' Training Corps Infantry units and the Red and White Courses at Citizens' Military Training Camps. The second volume deals with the advance course in Reserve Officers' Training Corps Units and the Blue Course of the Citizens' Military Training Camps. Both also include various other subjects not directly connected with the courses used as a basis.

For the purpose intended, this publication fills the need admirably. It is complete in itself and no other book on training is needed by the Infantry Company commander for the efficient development of his unit.

The Writer's Index. By J. M. Manly and Edith Rickert. New York: Henry Holt & Co. 262 pages. Price, $1.50.

This is a handy desk volume containing much valuable data of use to the writer. He is told how to find material, prepare working bibligraphies, use a library, prepare notes, and, in general, how to work up his available resources into acceptable form.

The preparation of manuscripts for the printer, reading proof, punctuation, capitalization, good usage in words and phrases, rules of sentence structure, etc., are treated in a most attractive way.

The index is essentially a manual for the use of teachers and students in that its method of compilation easily adapts it to classroom use. But it is also a handbook for the writer in the same sense that an engineering handbook serves the engineer. One may refer to any disputed question of literary form or style or good usage and, like finding a log, one can "find the answer" to his literary problem. The book is novel and should fill a great need.

Scales and Weighing—Their Industrial Application. By Herbert T. Wade. New York: The Ronald Press Company. 458 pages and Bibliography. Price, $6.00.

The author presents in non-technical form general principles of weighing, he emphasizes the importance of weighing problems and describes in detail some of the methods of solution in industry. The importance of accurate and convenient weighing devices in buying and selling, as well as in plant management, such as the control of processes, cost analyses, etc., are set forth. The book also covers the uses of weighing devices in dynamometer tests and testing machines of various types.

General features covering good weighing equipment and good weighing practice are enumerated and the results contrasted with those obtained with faulty equipment and practices. The essentials of suitable weighing equipment are given for each problem, together with accepted requirements for accuracy, convenience, speed of operation, etc. Then there are described and illustrated one or more types of commercial scales adapted to the particular problem, together with principles which should govern the installation, checking and repair. There is a discussion of the accuracy requirements for various types of scales, these requirements being based upon the value of the commodity being weighed or the importance of accuracy in the control of a process as against the time and equipment required to secure extreme accuracy.

In connection with the various specific uses of weighing devices, brief descriptions are given of practically every type in common use, ranging from the fine chemical balances up through the various types of balances, specialized scales, such as the indicating, computing, recording and automatic, to the large track scales with capacities close to a million pounds. Dynamometers of the elementary type, using an ordinary platform scale as well as special indicating types are described, also various types of testing machines, ranging from small machines for testing of yarns, paper, cloth, rubber, etc., to the large machines used in testing metals and built up metal structures. Among the latter are enumerated the large tension machines up to over two million pounds capacity and compression machines up to ten million pounds.

Having described various weighing devices, and having given rules governing the installation, maintenance, etc., the author describes typical well organized weighing systems as used in several large industrial plants. These systems cover complete organizations to supervise the selection, installation, operation, testing and repair of the various weighing devices selected or specially designed for the particular problem.

Not the least valuable part of the book is the bibliography of several pages, giving titles and nature of contents of various U. S. Bureau of Standards Circulars, U. S. Bureau of Standards Technologic Papers, Periodicals, Miscellaneous Reports, Technical Reference Works, General Treatises—English, General Treatises—Foreign Languages, and Trade Catalogues.

The book can be read with profit by anyone in any way connected with weighing problems or their applications. It should be of great value to the large number of people who use weighing devices and who still think that all that is required to get satisfactory results is to procure a scale of sufficient capacity and perhaps have it tested when installed, but after that pay little attention to its operation, inspection or repair, except possibly to occasionally balance the beam or to replace parts which may be actually broken.

Organized Business Knowledge. By Joseph French Johnson, President, Alexander Hamilton Institute; Dean, New York University, School of Commerce, Accounts, and Finance. New York: B. C. Forbes Publishing Company. 13 chapters, 204 pages. Illustrated. Price, $2.00.

"The science of business is but an incorporation of all that is best in what has preceded us. It is not that the principles of business have changed so much, but the manner of conducting it has changed materially and progressed." It is not necessary to search far into the past to find the "hard-headed business man" whose sole means of assembling business knowledge and acumen was in the school of experience. Times have changed, however, and commerce has steadily become more complicated in its methods. Experience has become the longest road to a mastery of sound economic methods in business. It is natural, therefore, that the attention of progressive minds has been turned to the organization of business knowledge along much the same lines as have been long employed for the learned professions. Schools of commerce have been the logical outcome of this tendency. Business men must be trained in schools in order that the long road of knowledge by experience may be shortened as much as possible.

Dean Johnson has attempted in this book to digest in interesting fashion the outlines of organized business training. He does not attempt a detailed account of such training. "Rather has the effort been to whet the appetite; to sketch a picture of what present day management problems involve." The purpose has been well fulfilled. A desire is created to go further into the subject.

One is somewhat surprised to find, however, that the publisher has seen fit to advertise other publications of the firm at the end of the book itself. Magazine and other advertisements somewhat detract from the excellent impression created by the author in the treatment of an interesting subject.

The Labor Theory of Value in Karl Marx. By H. W. B. Joseph. London: Oxford University Press. 174 pages. Price, $1.50.

The Marxian doctrine that value is derived from labor is exhaustively examined and analyzed in this book. The author carefully digests *Das Kapital* and clearly states the doctrine in its two-fold aspect: as an immutable fact of exchange, and as an inherent right of labor.

Of course, the subject matter of this work has been discussed and discarded by economists since the very days of its promulgation. There is a pleasant reaction brought about by this little book which states the case against Marx so clearly and so well. Its appeal is not alone in the quality of the treatment but also in the fact that it comprises an authentic yet concise account of an economic theory that often lies buried amid the cold *'hic jacets'* in the more pretentious treatises on economics.

Samuel Adams, Promoter of the American Revolution. A study in Psychology and Politics. By Ralph Volney Harlow, Ph. D. New York: Henry Holt & Co. Price, $3.00.

Born in 1722, by the time he had reached the age of forty, Samuel Adams had engaged in the practice of law and in business and had held public office. In all of these he had failed. The explanation of his rapid rise to fame after 1763 offers a fertile field for speculation for the psychologist.

The author has sought to show the man at work, and to make clear why he followed his particular course. This study deals with the processes of the Revolution, with extra-legal assemblages, with the manufacture of public opinion; in short, with the complicated, underground machinery necessary to all revolutions. It is concerned with the psychological side of revolution and the mental processes of the revolutionary personality.

The author finds in the press of the times and in published records and correspondence an abundance of evidence to justify his conclusion that the revolutionary movement was far from being the result of the spontaneous popular action which earlier historians have represented it to be.

Recent Patents

Brief Descriptions of Inventions of Interest to Ordnance Engineers

Compiled by W. N. Roach, Chief, Patent Section, Office of the Chief of Ordnance

SINCE our last report there have been a number of patents issued which are of particular interest to those interested in the Ordnance art of which the following is a fairly representative list.

Artillery

Bryan P. Joyce of Rock Island Arsenal has also been granted patent No. 1,480,557, covering a recoil mechanism. This recoil mechanism consists of a sleeve surrounding the gun in which is mounted a counter recoil spring, the front end of the spring abutting a ring detachably locked to the gun barrel and slidable in the sleeve, means being provided for preventing relative rotation of the gun and sleeve.

A floating piston is covered by patent No. 1,480,011, granted to Bryan P. Joyce of Rock Island Arsenal. This piston is provided with a grease chamber and with means for controlling the pressure within such grease chamber.

Arthur T. Dawson and George T. Buckham, assignors to Vickers, Ltd., have been granted patent No. 1,481,859, covering an ordnance sighting apparatus. This sighting device is intended primarily for antiaircraft firing. This invention as stated in the patent relates to ordnance sighting apparatus having a lateral deflection gear for displacing the sight in order to compensate for the speed of the target in a direction at right angles to the line of sight and provides means whereby the lateral adjustment of the sight to compensate for drift deviation is given or corrected through the intermediary of the lateral deflection gear of the sight in such a manner that the said compensation is in accordance with the tangent elevation only; for which purpose the index, or setting mark, appertaining to the lateral deflection dial may be automatically adjusted so that in resetting the lateral deflection gear to agree with the new position of the index, or setting mark, the required drift adjustment will be given.

An apparatus for lubricating the bore of firearms during firing is covered by patent No. 1,481,930, issued to Eugene Schneider, assignor to Schneider et Cie. The invention contemplates carrying the lubricant in the shell itself at a position forward of the rotating band and internal cavity in the usual cap or nose attached to the front end of the shell.

Arthur T. Dawson, George T. Buckham and Dorsey F. Asbury, assignors to the United States Ordnance Company, have been granted patent No. 1,482,118 for an ordnance breech mechanism. In this mechanism separate power-operated elements of the ram or piston and cylinder type are provided, one of which is used for locking and unlocking the breech screw for swinging the breech screw gear to and from its closing position, the former operating between the gear and the radial crank shaft or its equivalent and the other operating between the gear and the breech end of the gun.

A device for permitting variation of the capacity of explosive chambers in guns is disclosed in Patent No. 1,480,958, issued to Eugene Schneider, assignor to Schneider et Cie. A stopper or plug is provided which may be advanced to diminish the capacity of the explosive chamber or retracted to enlarge the capacity.

A high angle gun in which the parts extending to the rear of the trunnions are weighted so as to counterbalance the weight of the gun is disclosed in patent No. 1,464,171, issued to A. T. Dawson and George T. Buckham, assignors to Vickers, Ltd.

A sighting device having an independent line of sight in which the lateral movements of the sight occur in the plane of sight at all angles of elevation is disclosed in patent No. 1,471,472 issued to A. T. Dawson and George T. Buckham, assignors to Vickers, Ltd.

A special means for locking the gun cradle to the cradle lock is disclosed in patent No. 1,476,079, issued to Bryan P. Joyce of Rock Island Arsenal.

A novel traveling lock for gun carriages is covered by patent No. 1,475,952 also issued to Bryan P. Joyce.

Patent No. 1,475,186, issued to Bryan P. Joyce discloses a new means for securing trunnions to cradle forgings.

Patent No. 1,473,628, also issued to Bryan P. Joyce, covers a special trail for gun carriages provided with detachable spades.

Eugene Schneider, assignor to Schneider et Cie, has secured, in patent No. 1,477,980, a specific form of pedestal gun mount.

Means for varying the height of the line of fire of a gun mounted on a trail carriage provided with endless tracks is disclosed in patent No. 1,477,979, issued to Eugene Schneider, assignor to Schneider et Cie.

A gun carriage having a crank carriage axle in which the height of the line of fire may be varied and the gun elevated simultaneously is disclosed in patent No. 1,476,849, issued to Eugene Schneider, assignor to Schneider et Cie.

A gun provided with means for utilizing a portion of the gases of explosion to counteract the effect of recoil is disclosed in patent No. 1,469,918, issued to Ernest De Maine.

An improved form of base line telemeter is disclosed in patent No. 1,477,112, issued to O. Eppenstein, assignor to the firm of Carl Zeiss.

A gun provided with multiple powder chambers is covered in patent No. 1,477,078, issued to Emile Rimailho.

Patent No. 1,475,706, to Albert Konig, assignor to the firm of Carl Zeiss, covers a telemeter in which the two objectives are not united by an instrument body.

A specific firing mechanism is covered by patent No. 1,469,633, issued to Abner Y. Leech.

A sighting device intended primarily for use in anti-aircraft fire is covered by patent No. 1,468,712, issued to Hannibal C. Ford, assignor to Ford Instrument Company, Inc.

Patent No. 1,466,800, issued to Rees C. Morgan, assignor to Bethlehem Steel Company, discloses a method of constructing built-up guns so as to prevent relative rotation of the cylinders.

William T. Palmer, of Rock Island Arsenal, has secured through patent No. 1,469,240, a device for testing the recuperative power of a gun.

H. C. Zimmerman, an employee of the Ordnance Department, has been granted patent No. 1,483,921 for a gun carriage. This patent covers a carriage having an axle bent on an arc described about the spade as a center.

He has also been granted patent No. 1,483,151 for a gun trail. The object of the device covered by this patent is to provide a cheaply constructed gun trail which may be made of comparatively thin metal bent to the desired form.

Patent No. 1,483,161 has been granted to A. T. Dawson, G. T. Buckham and W. R. Pervis, assignors to Vickers, Ltd., for an ordnance breech mechanism. This patent covers a breech mechanism of the swinging-carrier type in which opening and closing of the breech is effected through a mechanism which is not of a self-locking character and which is provided with a self-locking device which operates to retain the carrier in any position.

L. J. F. Filloux has been granted patent No. 1,483,169 for a gun carriage. This patent covers a carriage of the split trail type in which traction tracks are mounted directly on each trail.

B. P. Joyce of Rock Island Arsenal has been granted patent No. 1,481,263 for a safety device for high angle guns. This patent covers a gun provided with mechanism whereby the gun may be quickly lowered from elevated position to horizontal or loading position and again re-elevated quickly to firing position in which means are provided for locking the firing mechanism against actuation until the gun has been brought to firing position.

B. P. Joyce has also been granted patent No. 1,481,644 for a cradle lock for gun carriages. The patent covers a support mounted on the carriage and adapted for pivotal engagement with a lug on the cradle, the support being adjustable by means of a cam mounted on the carriage.

B. P. Joyce has also been granted patent No. 1,486,902 for a recuperator mechanism for guns. This patent covers specific means for varying the flow of fluid to and from the recuperator.

Patent No. 1,484,274 for a level correction device for ordnance has been granted to A. L. Perham, assignor to Vickers, Ltd. This device consists of levels and pointers, so geared that when the levels are set to true horizontal the pointers will be moved to compensate for the angular position of the gun carriage and give the true angular elevation of the gun.

Patent No. 1,485,836 for a vehicle mount has been granted to H. Delano, G. A. Chadwick and S. V. Kemp, assignors to the United States. This patent is limited to a specific form of mount provided with traction tracks.

Eugene Schneider, assignor to Schneider et Cie, has been granted patent No. 1,487,695, for a multibarrel gun. This patent covers a gun provided with a plurality of barrels, the number being even, in which the recoil mechanism is so constructed that recoil of one barrel will cause running out of the other.

Patent No. 1,488,438 for device for regulating the flow of liquid in artillery brakes during return to battery, has been granted to E. Rimailho, assignor to Compagnie Des Forges & Acieries de la Marine & D'Homecourt. This patent is of a very limited character covering the specific combination of a vast number of elements comprising this particular brake mechanism.

E. Rimailho, assignor to Compagnie Des Forges & Acieries de la Marine & D'Homecourt, has also been granted patent No. 1,488,439 for a cannon with a variable charge. This patent covers a cannon having a normal powder chamber at the front of the breech and one or more additional chambers coaxial with and communicating therewith, such chambers increasing in diameter toward the rear, and inert plugs for insertion in the additional chambers in place of a charge, the plugs being adapted to be carried by the breech.

R. V. Morse, assignor to Morse Instrument Company, Inc., has been granted patent No. 1,483,235 for a system for transmitting settings. The device covered by this patent consists essentially of two rheostats or resistances, one located at the sending station and the other at the receiving station, a difference of potential applied to the ends thereof, the resistance at the receiving station also having in series therewith an adjustable resistance through manipulation of which the difference of potential at the end of such resistance may be made the same as that of the resistance at the sending station. A movable contact is provided to move along the resistance at the sending station and this contact is connected by a transmission line to a similar contact at the receiving station which latter contact has in series therewith an indicating instrument such as a volt meter. When the two contacts are set to similar points on the resistance no current will flow through the transmission line which effect will be indicated by the volt meter so that the correct setting may be known at the receiving station.

E. A. Sperry, assignor to Sperry Gyroscope Company, has been granted patent No. 1,487,282, for a fire control system. The system is one for determining the range and position in azimuth of a target with relation to a distant point from which the target may be visible.

Ammunition

Patents relating to ammunition were issued as follows:

A safety device for fuzes armed by rotation of a wind wheel is covered in patent No. 1,483,068, issued to Major William A. Borden, Ordnance Department.

Major J. H. Woodberry, Ordnance Department, has been granted patent No. 1,486,177 for a super-sensitive fuze in which a rotatable member normally prevents communication between the primer and booster, said member being locked by a centrifugal element which in turn is

locked by an inertia element, the latter element carrying a means for priming the primer. This fuze is designed as a combination percussion and delay fuze.

O. D. Lucas, assignor to Vickers, Ltd., has been granted patent No. 1,486,593 for a time fuze. This is a mechanical fuze in which a wind-wheel operates a train of reducing gears through which the firing spring is tensioned and released. The gears are so arranged that the relationship of the gears may be changed to set the fuze for the time desired.

A patent for a bomb body, No. 1,483,864, has been granted to Major William A. Bordon and Capt. C. H. M. Roberts, Ordnance Department. This patent relates to a special structure for securing the base cap and fin assembly to the bomb body.

Patent No. 1,488,182 granted to G. T. Whelton, for a projectile, covers a projectile containing a propellant charge which is ignited at a predetermined time in the flight of the projectile to expel from the nose thereof a plurality of missiles which are connected by chain, wire or the like and which are adopted to spread over a considerable area. This projectile is presumed to be of use against aircraft, barbed wire entanglements, etc.

A high explosive is covered in patent No. 1,485,003, issued to G. A. Woodbury, assignor to E. I. DuPont de Nemours & Co. The principal ingredient of this explosive is β-nitroethylnitrate and mixtures of the same with ethylene glycoldinitrate.

R. L. Hill, assignors to Atlas Powder Company, has been granted patent No. 1,483,007, for an ammonium nitrate explosive. This explosive consists of nitroaromatics of which at least 50 per cent is trinitrotoluene, liquid organic nitrate or like mixtures of organic nitrates, ammonium nitrate in sufficient quantity to give the desired strength and non-explosive inorganic nitrates to act as a filler and furnish the necessary oxygen.

Patent No. 1,483,197, granted to James H. Reed, assignor to the International Nitrogen Company for a process of reducing nitrogen-containing compounds. The process consists essentially in conducting the material to be nitrified through a progressively heated zone and subjecting the carbide in the zone to an atmosphere of nitrogen having an activating agent mingled with it. This may be done under superatmospheric pressure and the activating agent may be successively applied during the operation.

John C. Clancy, assignor to the Nitrogen Corporation, has been granted four patents. The first, 1,483,411, is for a process of ammonia synthesis and a means for effecting the same. This process consists essentially in purifying the gases by bringing them into contact with a metallic carbide, then into contact with an alkalinous oxid, and then passing the gases through a catalyst containing a cyanamid compound of alkalinous metal under heat and pressure.

The second, 1,483,414, is for process for the synthetic production of ammonia. The process comprises passing the gases into contact with an alkalinous carbo-nitrid intimately mixed with iron, synthesizing ammonia from the gases and effecting the regeneration of the mixture at intervals during the operation by passing ammonia gas in the mixture.

The third, 1,483,412, is an ammonia synthesis catalyst. This patent covers a catalyst formed by heating an alkalinous metal salt with a catalytically active metal in the presence of a reducing agent and a gas containing nitrogen and drying the substance formed with liquid anhydrous ammonia.

The fourth, 1,483,414—is for a process of regenerating ammonia synthesis catalysts. This process comprises reacting upon the catalyst with ammonia gas in the presence of acetylene and at an elevated temperature and under pressure.

Small Arms

An operating slide and handle for machine guns intended for use principally on an aircraft gun is covered by patent No. 1,460,415, issued to Capt. Walter T. Gorton of Ordnance Department, U. S. A.

S. Wiley of Picatinny Arsenal, has been granted patent No. 1,483,146, for a double-barrel firearm, the upper barrel being an ordinary rifle barrel and the lower barrel being designed as a grenade thrower, the barrels being connected by means of a port which allows the gases generated from the firing of an ordinary service cartridge to expand into the larger lower barrel to expel a grenade therefrom. Means are provided for closing the port so that the arm may be used as an ordinary rifle.

W. R. Bull, Springfield Armory, has been granted patent No. 1,483,867 for a guide designed to convey a cartridge belt over the machine gun so that the same may be fed into the opposite side of the gun.

Patent No. 1,483,925 has been granted to L. C. Booth for a base for mounting a peep sight on the sliding breech bolt of a rifle to the rear of the firing pin.

G. Vincon has been granted patent No. 1,484,163 for an automatic firearm. The object of this invention is to provide a trigger mechanism which will permit the firing of single shots or bursts of a fixed number of shots. This object is accomplished by means of a ratchet wheel in connection with the trigger mechanism.

Patent No. 1,484,687 has been granted to D. D. Howard for a flinch indicator for firearms. This device consists of a bracket to be attached to the firearm carrying a pressure gage to which a bulb is attached by means of a short length of rubber hose and a grip plate is provided between which and the hand grip of the stock the rubber bulb is placed.

E. S. Pomeroy, assignor to Smith & Wesson, Inc., has been granted patent No. 1,484,671, a safety device whereby, such as a pistol, the firing mechanism is locked when the cartridge magazine is removed from the arm, so that a cartridge left in the chamber can not be exploded by the firing mechanism.

J. S. Johnson has been granted patent No. 1,485,460 for a machine gun. This patent shows a light machine gun which is assembled without screws so that no tools are necessary in taking the gun down or reassembling it, and the gun is designed to be fired automatically or for single shots.

H. Schmeisser has been granted patent No. 1,486,497 for a self-loading pistol with a fixed barrel. This patent covers a safety device consisting of a lock which must be operated to lock the sear before the cartridge magazine may be removed from the pistol.

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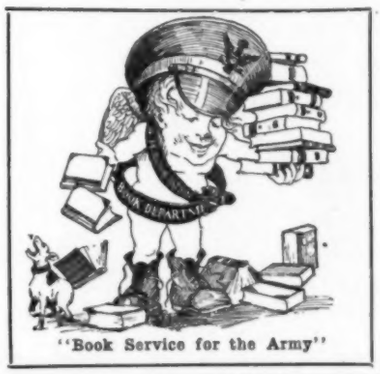

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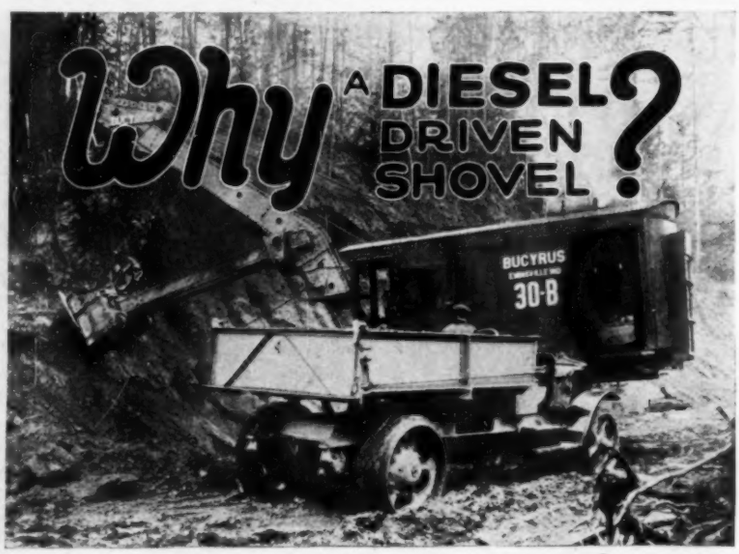

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